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EXTRACTED VERSION

OPERATION CASTLE

Radiological Safety, Final Report

Volume II

Headquarters
Joint Task Force Seven
Technical Branch, J-3 Division
Washington, DC

Spring 1954

NOTICE:

This is an extract of Operation CASTLE, Volume II.

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report is designed to cover the overall Operation Castle radiological safety matters from the viewpoint of those issues of direct concern to Headquarters, Joint Task Force Seven. It was written for the express purpose of assisting in the development of future radiological safety plans by presenting detailed discussion of the problems and solutions arising during Operation Castle.

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FOREWORD

Classified material has been removed in order to make the information available on an unclassified, open publication basis, to any interested parties. The effort to declassify this report has been accomplished specifically to support the Department of Defense Nuclear Test Personnel Review (NTPR) Program. The objective is to facilitate studies of the low levels of radiation received by some individuals during the atmospheric nuclear test program by making as much information as possible available to all interested parties.

The material which has been deleted is either currently classified as Restricted Data or Formerly Restricted Data under the provisions of the Atomic Energy Act of 1954 (as amended), or is National Security Information, or has been determined to be critical military information which could reveal system or equipment vulnerabilities and is, therefore, not appropriate for open publication.

The Defense Nuclear Agency (DNA) believes that though all classified material has been deleted, the report accurately portrays the contents of the original. DNA also believes that the deleted material is of little or no significance to studies into the amounts, or types, of radiation received by any individuals during the atmospheric nuclear test program.

TAB "I"

PROBABILITY OF OCCURRENCE OF UPPER WINDS WITH SOUTHERLY COMPONENTS IN THE ENIWETOK-BIKINI AREA

2 Incls:
1. Percentage frequency Eniwetok winds with southerly components (1 chart)
2. Wind-Time Graph (2 charts)

PROBABILITY OF OCCURRENCE OF UPPER WINDS WITH SOUTHERLY COMPONENTS IN THE ENIWETOK-BIKINI AREA

(Extract from detailed studies made on this subject by the Task Force Weather Central.)

Winds with southerly components at Eniwetok are much less prevalent than winds with northerly components. Upper wind data obtained by rawinsonde equipment since 1945 have been compiled. The frequency of occurrence of winds with southerly components is shown in the attached graph (Incl 1).

The upper portion of the graph shows that winds with southerly components (i.e., east-southeast clockwise through west-southwest) have occurred about thirty-five per cent of the time during the months of March through July at levels of about 10,000 feet. The lower portion of the graph shows that southeast through southwest winds have occurred about twenty per cent of the time during the same months at the same levels. The differences are due to the high frequency of east-southeast winds at about 10,000 and 16,000 feet and the high frequency of west-southwest winds above 25,000 feet. A slight trend for higher occurrence of winds with southerly components is indicated as the season progresses.

Extreme care must be taken in drawing conclusions from these data for three reasons:

1. The sample is small. The 49,000-foot data consist of less than 100 observations for March and April.

2. The variation of Marshall Islands weather for a given month during successive years may be greater than the variation during successive months. Note the high frequency of southerly winds at 49,000 to 50,000 feet during March as compared to April, May and June. The weather of March 1951 constituted most of this abnormality.

3. The data are tabulated for each level without reference to adjacent levels.

To evaluate the importance of the third factor, Item 3 above, a time-wind graph of Eniwetok winds has been analyzed for the period 1 January through 14 May 1954 (Incl 2). The winds aloft at Eniwetok and Bikini were very similar during the entire period except from 23 April through 5 May. The winds were more southerly at Bikini than at Eniwetok during that period; and Bikini winds are shown for comparison purposes. From this graph, data were obtained as to the simultaneous occurrence of southerly winds at 50,000 feet and at levels below. The results are shown in Table I following:

ALTITUDES	DIRECTIONS 120° thru 240°	100° thru 260°
50,000 to 30,000	3.4% (16)	10.8% (51)
50,000 to 20,000	2.1% (10)	6.0% (29)
50,000 to 10,000	.4% (2)	2.3% (11)

Note: Percentage frequency of winds of given directions occurring simultaneously at all levels below 50,000 feet. (474 observations during period 1 January through 14 May 1954. Cases in parenthesis.)

Table 2 following, shows that winds with southerly components have occurred as frequently during these months of 1954 as they did in past years.

TABLE 2

194[illegible] 1946, 1950, 1951 & 1952		1954	
[illegible],000 ft.	32%	10,000 ft.	30%
[illegible]5,000 ft.	21%	25,000 ft.	26%
50,000 ft.	35%	50,000 ft.	40%

Note: Percentage frequency of winds with southerly components January, February, March, April through mid-May 1954 as compared to previous years.

From the above tables, the following conclusions are drawn:

1. The upper winds during CASTLE were as favorable as past years for such an operation; this was a fairly "normal" year.

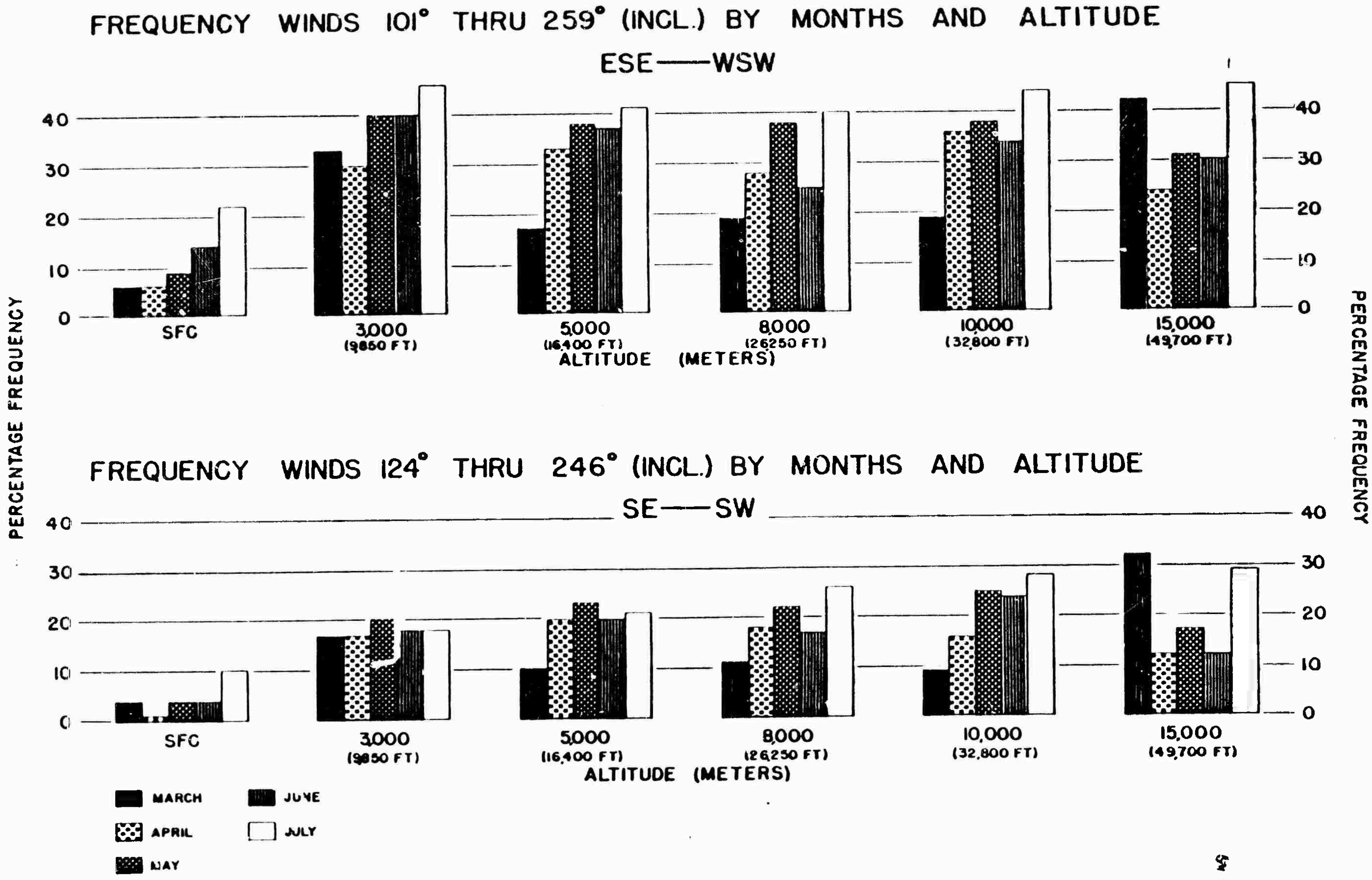
2. Winds with pronounced southerly components (SE through SW) at all levels between 10,000 and 50,000 feet occur simultaneously about one every fourteen times (i.e. 2 times in 28 cases) that winds with southerly components occur at 50,000 feet. Winds with pronounced southerly components at all levels can be expected to occur about twice per month.

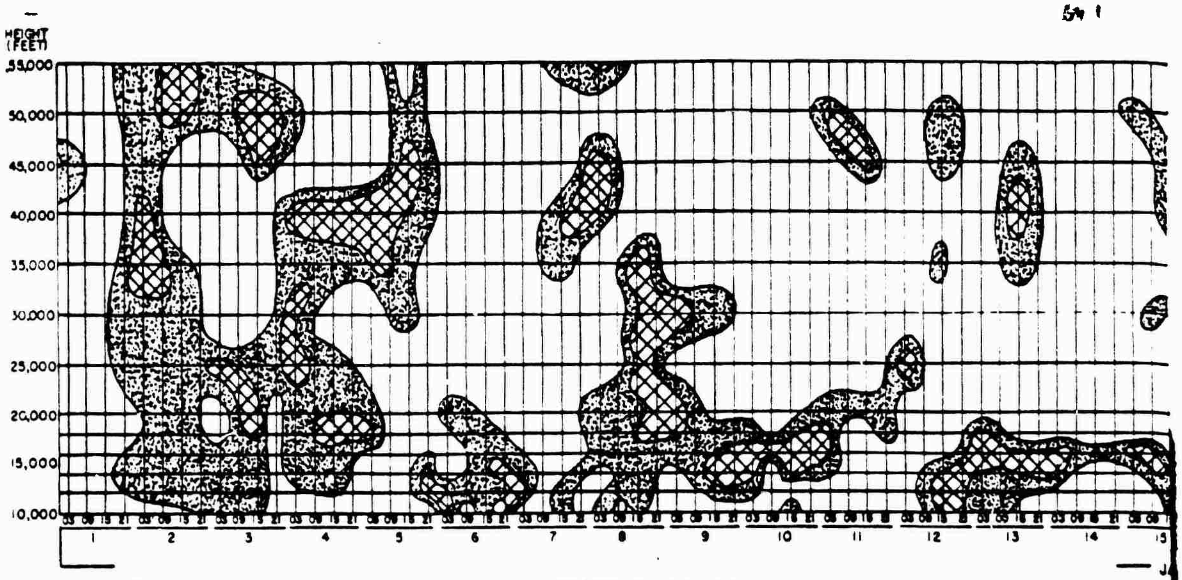
3. BRAVO and ROMEO events of CASTLE occurred on the best possible days during March though a more favorable day for BRAVO event would have been 28 February local time. ROMEO day was the most favorable of the entire month. KOON was detonated on the next possible day. While UNION and YANKEE devices were detonated on the next occurrences of acceptable wind conditions, the conditions were not as markedly acceptable as on former test days. The

winds were definitely more favorable at Bikini than at Eniwetok. NECTAR was detonated on the very next favorable day (Incl 2).

2 Incl
1. Percentage frequency Eniwetok winds with southerly components (1 Chart).
2. Wind Time Graph (2 Charts).

PERCENTAGE FREQUENCY ENIWETOK WINDS WITH SOUTHERLY COMPONENTS



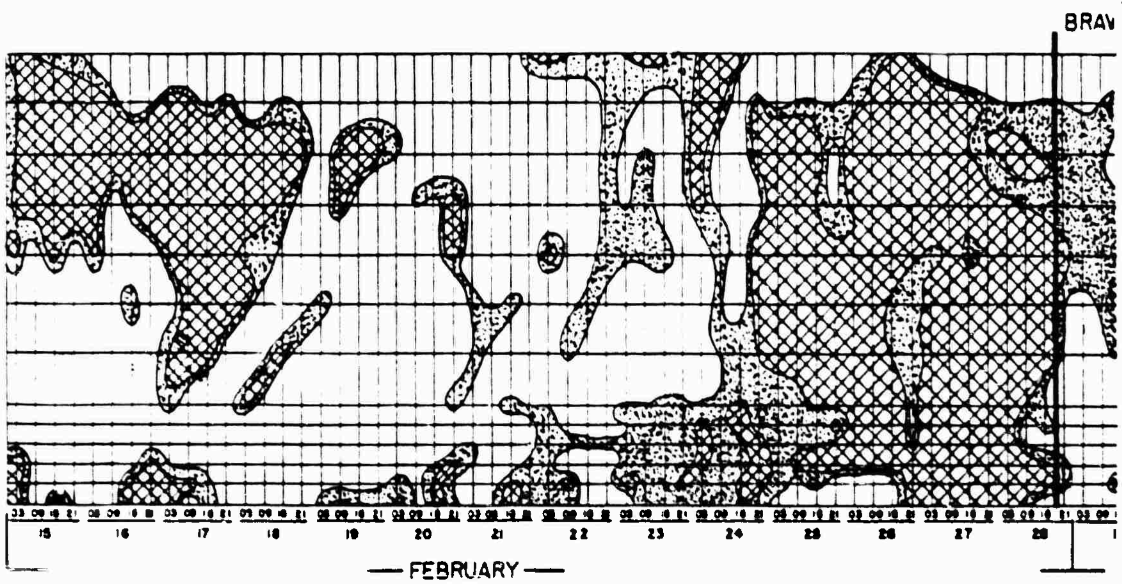


KEY-SHADED AREAS-WINDS WITH SOUTHERLY COMPONENTS

WIND DIRECTIONS 100°, 110°, 250° & 260°

WIND DIRECTIONS 120° CLOCKWISE THRU 240°

ALL TIMES AND DAT



KEY-SHADED AREAS-WINDS WITH SOUTHERLY COMPONENTS

WIND DIRECTION 100°, 110°, 250° & 260°

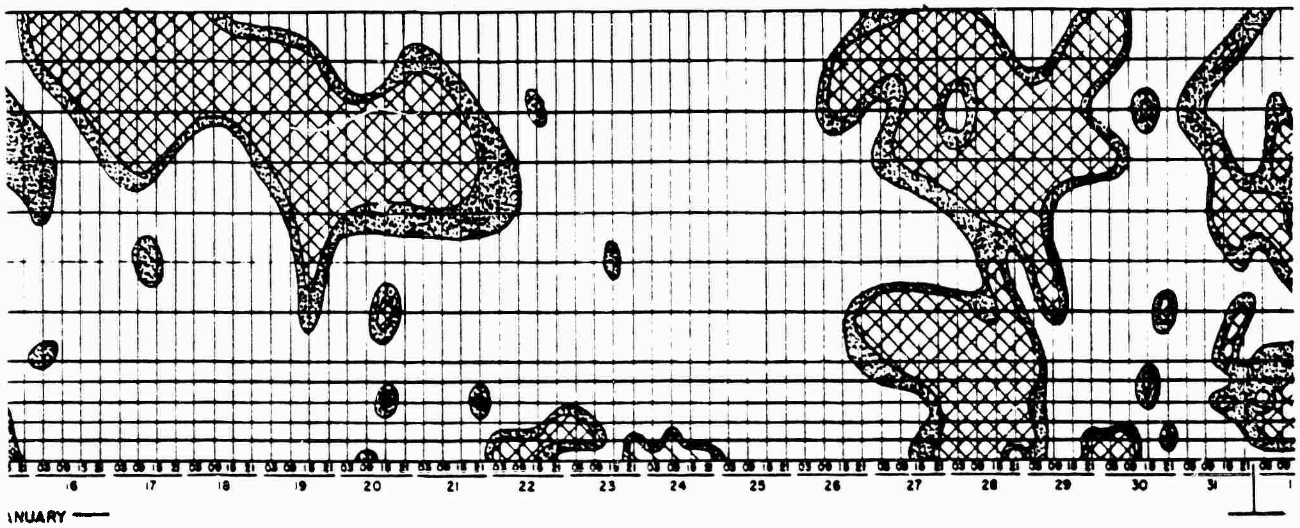
WIND DIRECTION 120° CLOCKWISE THRU 240°

ALL TIMES AND DATE

WIND TIME GRAPH

ENIWETOK ATOLL , M.I

1 JANUARY THROUGH 14 FEBRUARY, 1954

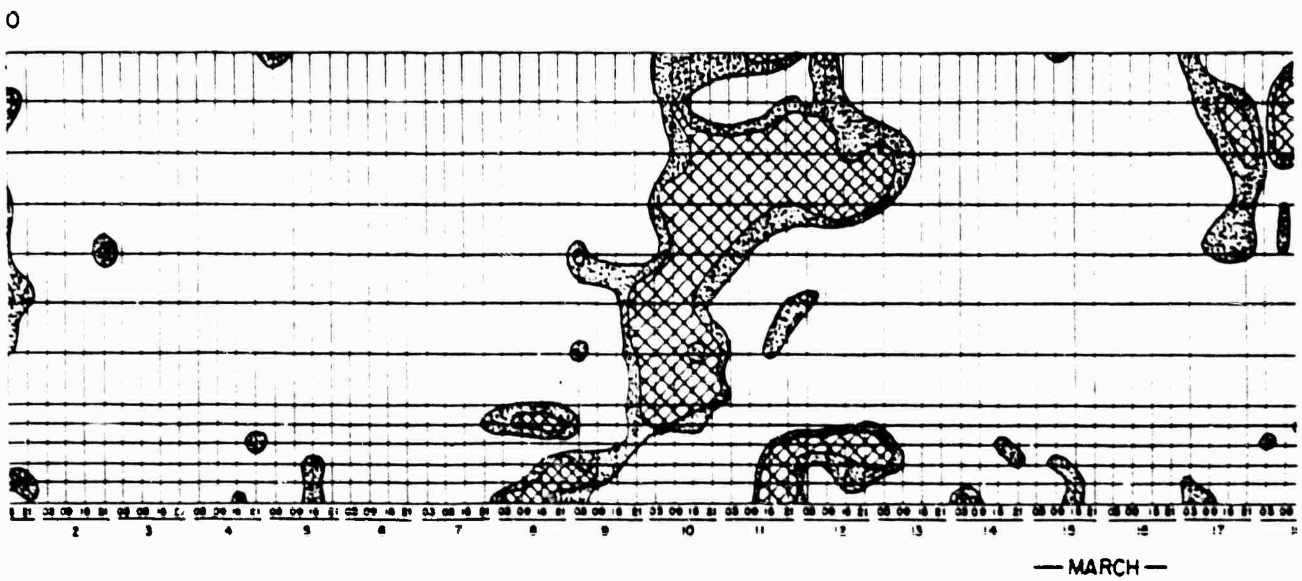


'ES - GREENWICH CIVIL TIME

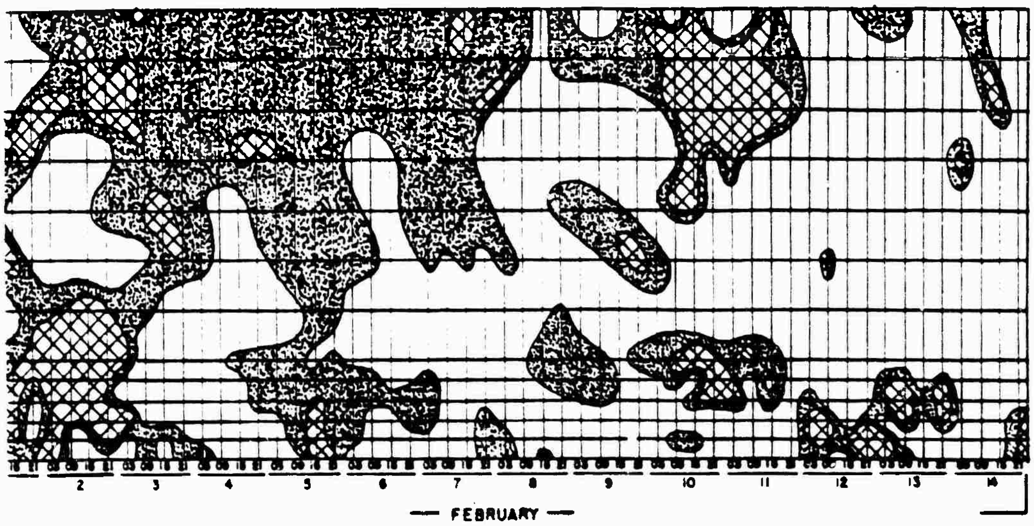
WIND TIME GRAPH, (CON'T)

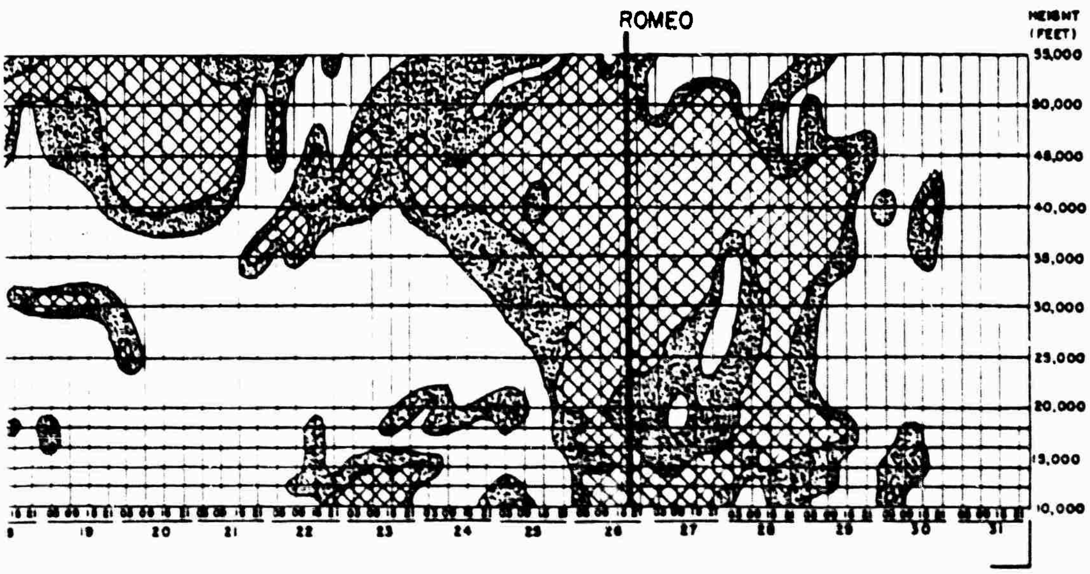
ENIWETOK ATOLL, MI

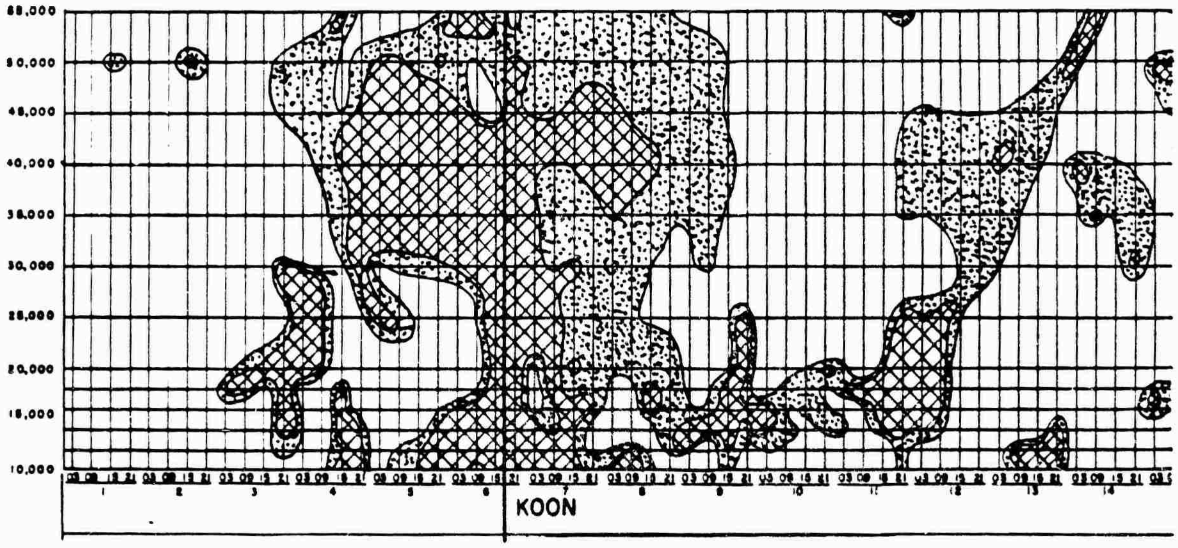
15 FEBRUARY THROUGH 31 MARCH, 1954



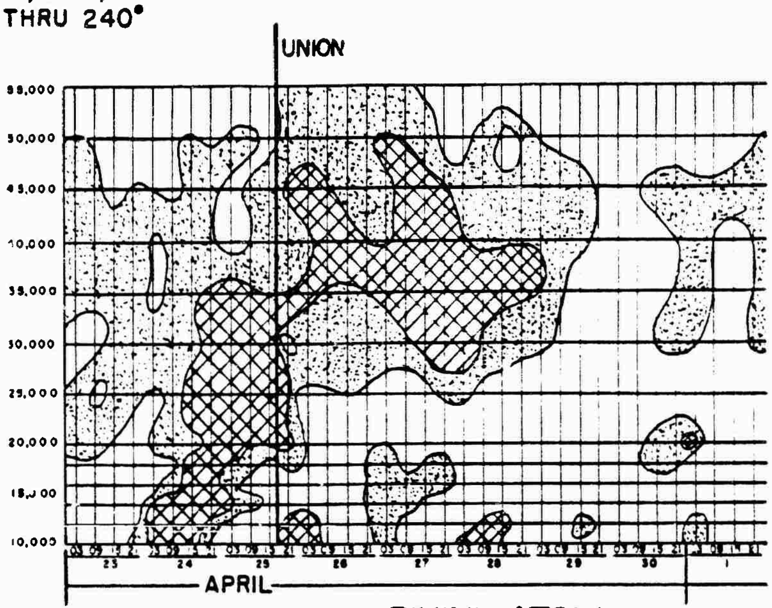
S - GREENWICH CIVIL TIME


2 3 4 5 6 7 8 9 10 11 12 13 14
FEBRUARY


ROMEO
HEIGHT (FEET)
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
19 20 21 22 23 24 25 26 27 28 29 30 31

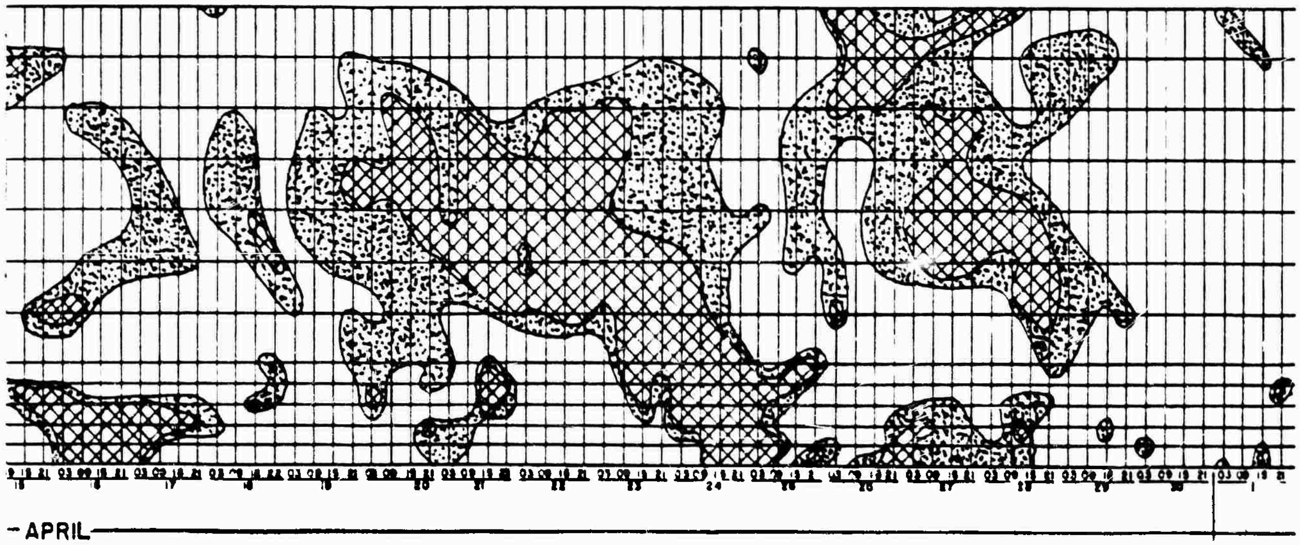

50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
1
2
3
4
5
6
7
8
9
10
12
13
14
KOON

WIND TIME GRAPH
BIKINI ATOLL, M.I.
23 APRIL - 5 MAY, 54
100°, 110°, 250°, & 260°
120° THRU 240°

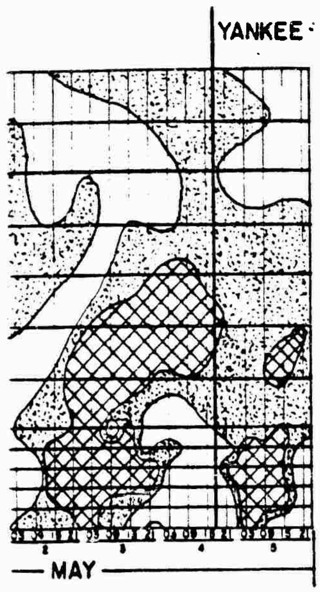


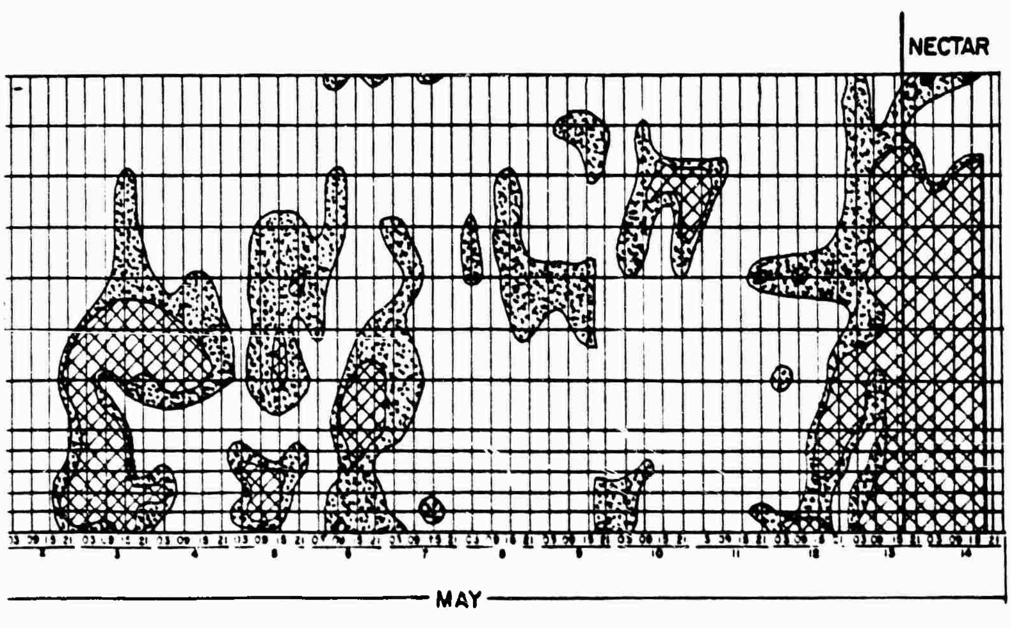
BIKINI ATOLL

WIND TIME GRAPH
ENIWETOK ATOLL, M.I.
1 APRIL - 14 MAY, 1954
100°, 110°, 250° & 260°
120° CLOCKWISE THRU 240°



ENIWETOK ATOLL





I-3c

TAB "J"

EXTRACT FROM TG 7.3 FINAL REPORT
(RADIOLOGICAL AND MEDICAL SECTIONS)

TAB J

Part 11a - Radiological Safety

1. Discussion

A temporary washdown system consisting of hoses and special nozzles connected to the fire main system, like that used in IVY, was installed by a BuShips representative on all manned ships engaged in CASTLE, with the exception of the USS TAWAKONI. The TAWAKONI reported to CTG 7.3 for the operation with a washdown system already installed by the ship's force from standard ship's fire fighting equipment (hoses, nozzles and applicators), and this system was found quite satisfactory and was used throughout the operation as necessary. The theory behind a washdown system is that radioactive particles landing on a dry deck will tend to settle in pores, cracks and fissures, while nearly all of the same particles falling on a wet deck with water flowing over it will be carried over the side. This theory is well borne out by the results of the ships in CASTLE, including the experiment with two YAGs, only one of which carried a washdown system. The washdown systems reduced contamination of weather surfaces to a small fraction of what it was on surfaces not protected by a washdown system.

It was found late in the operation that large areas of the sea's surface are significantly radioactive after a "bargo" shot. (Although there is no positive evidence on the subject, there is reason to believe that this effect is also present on "land" shots though probably to a much smaller degree). These areas may extend for several hundred miles downwind from the shot site and persist for several days. Diffusion and settling seemed to be slow, decreased activity resulting mainly from radiological decay. Intensity was fairly even through the area and dropped to zero in less than a mile at the edges. It is suspected that, before this discovery was definite, in a few cases ships entered an area of this type, mistook the radiation from the contaminated sea for fallout, and turned on the washdown system. At any rate, in some cases the washdown system did not reduce radiation readings. Readings did reduce sharply at a later time apparently when the ship left the area where radiation had been encountered. After leaving these areas ships reported radiation had dropped to almost zero.

The washdown hose deteriorated somewhat during the operation; it ruptured occasionally from the water pressure, and its porous surface was hard to decontaminate.

The PC 1546 had only a low fire main pump capacity; so a P-500 pump was installed to supplement the ship's fire main pumps. This proved unsatisfactory because:

a. It was difficult to maintain water suction for the P-500 when underway;

b. Pump stoppages were frequent due to wet engine;

c. Pump stoppages occured due to fuel exhaustion;

d. Personnel tending the pump were exposed to radiation.

The problem was solved more or less satisfactorily by using the fire main pumps only and decreasing the size of the washdown system nozzles to a point where enough pressure could be maintained in the system to give a relatively small but fairly uniform spray coverage over the ship.

During operation of the washdown systems it was found necessary on all ships to have a few personnel topside and exposed to radiation in order to clear fire main strainers, replace ruptured hoses, and to take kinks out of the hoses when the washdown system was first turned on.

To facilitate decontamination of helicopters returning to the BAIROKO after radiological exposure, a large (60 ft x 70 ft) canvas rectangle was constructed of 20 ounce canvas. The tarpaulin was treated with canvas preservative for water proofing. When the tarpaulin was in place aft of the elevator the sides were raised by use of stanchions and wire cable to form a so-called "bathtub". Fresh water under pressure was provided on the flight deck by using a P-500 pump connected to fresh water mains below decks. The "bathtub" was equipped with two drains which were tended over the side.

Protective clothing recommended to the ships included coveralls, marine cap, rubber boots and rubber gloves. This clothing was found satisfactory for keeping the body uncontaminated, and is much more practicable for work in hot climates than waterproof suits. Special plastic suits were used in Project 6.4 during decontamination. Their use was abandoned because personnel suffered from heat exhaustion after about half an hour of work.

All units of TG 7.3 were given an atomic defense inspection. On ships this consisted of an atomic defense exercise and an inspection of ship's closure of gas tight envelope, decontamination stations, washdown system in operation, Radiological Defense Bill, radiac equipment, decontamination equipment, and pre-contamination preparation of the ship. Additional observers as required were obtained from other ships to assist in these inspections. The Atomic Defense Exercises were conducted similarly to standard naval battle problems except that they simulated expected CASTLE conditions rather than battle conditions. For example, the problem usually started assuming that a device had been exploded several hours before and that the ship was in a normal steaming condition. Using previously prepared lists, observers then told monitors the simulated readings according to the designed problem which had been worked out in detail.

Although all ships had spent considerable time and effort on Radiological Defense, the inspections brought to light numerous small deficiencies which were corrected. Lectures were given by the inspecting officer and were followed by question and answer periods to repair party personnel during the inspection. These lectures served to promote respect for, and at the same time allay unwarranted fear and apprehension of, the effects of radiation. The inspections instilled in the ship's personnel confidence in their ability to protect themselves from radiation and thus improved morale in many cases. All inspections were considered satisfactory, and subsequent events proved their worth.

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Usually the Atomic Defense Bill was based on the standard bill for the type ship. The type standard was satisfactory in all cases. However, a supplement, detailing directions on operation of the washdown system, was required for each ship.

A serious problem encountered by all ships is how to operate the engineering plant in heavy fallout without excessive contamination of the engineering spaces. Large volumes of air are necessary to cool some of these spaces, especially when operating at or near full power, as would very likely be done in battle. In many ships the air required by boilers and diesel engines is drawn from the engineering space rather than from topside, necessitating a large flow of air through the engineering space. Nevertheless, in CASTLE, even with the washdown systems in operation the engineering spaces of ships were contaminated much less than the weather decks, and, in general, engineering personnel received less radiation than deck personnel. These results might not have been obtained had the ships been operating in fallout at full power. In the absence of scientific confirmation, the following conjectures are made:

a. Larger radioactive particles are not drawn into engineering spaces due to their size and weight.

b. A large proportion of the smaller radioactive particles which are drawn into engineering spaces are expelled through the exhaust systems, boilers and diesel engines.

c. Radioactive particles are possibly trapped in the washdown spray and washed overboard instead of entering with the air.

A central radiac repair center and a TG 7.3 radiac equipment pool were maintained on board the BAIROKO by two Electronics Technicians assigned from the Staff of CTG 7.3. This force was sufficient to calibrate all instruments of TG 7.3 brought to them for calibration, and to repair all radiac instruments which ships' personnel were unable to repair. In addition, these ETs instructed all ships' personnel who required instruction in use and maintenance of radiac equipment. Monitoring drills were made realistic by the use of radiation sources.

On 1 March 1954, at 0645M, the first nuclear explosion (BRAVO) of Operation CASTLE was detonated. Prior to the detonation, ships of Task Group 7.3 had been deployed at sea generally in the southeast quadrant from ground zero. This disposition and its location were based on four principal factors, (a) the latest CJTF SEVEN radex, (b) the requirements of the Commander Scientific Task Group (CTG 7.1) that ESTES (AGC-12) and CURTISS (AV-4) be positioned about 12 miles from ENYU Island for reliable UHF communications and Raydist purposes; (c) the requirement that ships be disposed at safe distances (at least 30 miles) from ground zero to avoid harmful heat, and blast effects, and (d) the requirement of reasonable concentration for communications and control purposes. Prior to the detonation and because later wind data began to indicate an easterly component, some of the smaller and slower units were directed to move to the south, but the larger ships were retained in the localities indicated in view of the foregoing requirements (b) and (d) and the expressed desire of the JTF Commander that they not be moved. Because of the additional requirements for early helicopter survey trips and the early dispatch by helicopter of an emergency airfield crew for the airstrip on the ENIWETOK Island group, the large ships were retained generally in their pre-shot positions after the detonation until about 0800M, when sudden and rapidly increasing radioactive fallout was detected on some ships. At this time, all ships were ordered to take all possible radiological defense damage control measures, including the employment of washdown systems, and to proceed to the south at best speed.

Commencing about 0800M, highly radioactive, visible, white particles, about the size of pinheads, began to fall on BAIROKO, PHILIP, ESTES and CURTISS. At this time BAIROKO was about 31 miles from ground zero. In spite of the continuous use of washdown systems, concentrations of up to several roentgens per hour built up on BAIROKO and PHILIP (plane guard for BAIROKO), with average readings reaching 500 and 750 milliroentgens per hour, respectively. The fallout pattern was not symmetrical, since both ESTES and CURTISS, approximately the same distance from ground zero as BAIROKO but on opposite sides of her, received less contamination. Other ships, including those which had been moved southward before the detonation, received none of this early fallout.

In addition to the early heavy fallout encountered by some ships during the morning, in the afternoon and early evening of 1 March, light, invisible fallout was detected by all ships. This fallout commenced about 1300M, reached a maximum about 1800M and decreased to almost zero by 2400M. Average readings during this period reached 300 mr per hour, with maximum concentration up to 475 mr per hour. Ships experiencing this fallout were located in the general area between true bearings 110°T to 155°T from ground zero, distances from 20 to 70 miles.

Decontamination of the ships by the ships' own decontamination crews, plus natural radioactive decay, brought the radioactive intensity down rapidly. Appendix 11a-I shows average topside intensities in milliroentgens per hour (gamma only) of the ships receiving significant fallout. It will be noticed that while the BAIROKO and PHILIP were the most heavily contaminated in the beginning, the GYPSY was the most heavily contaminated one week later. It is believed that contamination clung to the GYPSY longer than to other ships because of the condition of her topside, which was quite rusty. Another factor tending to increase radioactive intensity on the GYPSY was her employment the first week after BRAVO to recover contaminated chains and mooring gear from the bottom of the lagoon.

Three (3) barges, ten (10) LCUs and ten (10) LCMs were anchored or moored in the southeast portion of the lagoon off ENYU Island (about 20 miles from ground zero) prior to the detonation, as it was not considered practicable nor safe to take them to sea in the prevailing weather. BELLE GROVE (LSD-2) had evacuated a full load of eighteen (18) other LCMs and one (1) AVR in her well at shot time. Those craft left in the lagoon suffered no damage from blast, heat or wave action, but all were heavily contaminated by radioactive fallout to such an extent that about twelve (12) hours after shot time, they had a radioactive intensity averaging several roentgens per hour. Subsequently, all were washed down with hoses from other vessels (the high pressure hoses of GYPSY proved particularly effective as GYPSY could maneuver in the close vicinity of these craft), followed by a thorough decontamination by additional hosings and scrubbings by decontamination personnel who, by this time, were able to board the craft. All these measures were sufficiently effective that average radioactive intensity of these craft by 22 March was only about two (2) mr per hour.

On 27 March 1954 the second nuclear explosion (ROMEO) was detonated. Experimental "Liberty" ships of project 6.4 were subjected to intense radioactive fallout as planned, but other ships received no early fallout. However, after about 37 hours, most of the other ships of Task Group 7.3 anchored in BIKINI Lagoon commenced receiving fallout which proved slight relative to that from BRAVO, the highest average topside intensity at any time being 42 mr per hour. Employment of washdown systems, vigorous decontamination, and natural radioactive decay steadily reduced contamination. Appendix 11c-II shows radioactive intensities of 13 ships at various times following ROMEO. These ships were in or near BIKINI

Lagoon. It will be noticed from this appendix that most of the fallout occurred between 40 and 48 hours after the explosion.

All shots subsequent to ROMEO produced no significant fallout on ships, except that the LST 762, which had been released from CASTLE and was enroute to Pearl Harbor, and the LST 975, which was accompanying the LST 762, received fallout from YANKEE at approximately 13°N, 177°E (approximately 700 miles from and 30 hours after the explosion). Average topside intensity was as much as 20 mr per hour at one time.

LCUs anchored in BIKINI Lagoon, and such LCMs that could not be taken to sea in BELLE GROVE, again received moderate to heavy fallout following YANKEE and UNION. Decontamination measures similar to those employed following BRAVO again proved effective.

Appendix 11a-III shows the contamination of ships at about the time of their release from the operation. The YAGs are not included as their decontamination is not complete at the time of writing this report. With the exception of LCUs and barges, there were no radiological health hazards on any ships listed in Appendix 11a-III when released from CASTLE. At that time, the higher radioactive intensities on these ships was limited to small areas such as anchor chains, towing cables, evaporators and condensers.

Naval aircraft were contaminated with radioactive material a number of times. However, decontamination measures kept radiological exposures of aircraft personnel to low values. There were no radiological health hazards on any naval aircraft when released from Operation CASTLE.

The seas were uniformily too rough to send LCUs into the open sea at shot time. The YFN was towed to sea for each BIKINI shot. Other barges and all LCUs at BIKINI were anchored or moored near ENYU Island for each BIKINI shot. As a result, these craft had to be decontaminated after BRAVO, UNION and YANKEE before use.

Task Unit 7 of Task Group 7.1 was charged with accomplishing photodosimetry for the entire Task Force. Because of favorable experiences on previous operations, original plans were to supply film badges to all personnel expected to receive significant amounts of radiation and to a representative 10% of other personnel. To accomplish its photodosimetry mission, Task Unit 7 had an air conditioned trailer, containing a complete photodosimetry laboratory, located on the hangar deck of the USS BAIROKO, a photodosimetry laboratory at the Radiological Safety Center, PARRY Island, ENIWETOK Atoll, and a Radiological Safety Center on ENIMAN Island, BIKINI Atoll where it was planned to maintain photodosimetry records. The first shot (BRAVO) contaminated ENIMAN Island so much that the Radiological Safety Center on it was not used thereafter, and Task Unit 7 then maintained photodosimetry records on the USS BAIROKO until near the end of the operation when the records were maintained at PARRY Island. BRAVO contaminated some of the ships to the point that it would have been most desirable to issue film badges to all personnel on them. However, neither the film badges nor the personnel for processing them were available to Task Unit 7 at the time (film badges were more plentiful later in the operation). Many people with no film badges received significant radiation; their radiation dosages were estimated and recorded, based on film badge readings of similarly exposed personnel, but it was impossible to do this accurately in many cases. It was originally planned by Task Unit 7 to maintain a card file, with a card for each person in the Task Force, recording accumulated exposure. After BRAVO, this plan was abandoned, and each unit of TG 7.3 was required to send an alphabetical roster of personnel in triplicate to Task Unit 7. These rosters were us[ed] by Task Unit 7 for recording accumulated exposures. In addition, each unit of TG 7.3 was required to maintain a card file recording accumulated exposure of all persons attached. These records included not only exposures of persons with film badges, but also estimated exposures of other persons based on film badge readings of people similarly exposed. Units had to be cautioned not to confuse film badge densities with film badge exposures. When film badges were sent to Task Unit 7, the name of the person wearing each badge and the names of people similarly exposed were attached.

As film badges became more plentiful they were distributed more widely, preference being given people expected to receive significant radiation and people who had already received a relatively large amount of radiation.

Fallout from BRAVO caused a large number of people, especially on the USS BAIROKO and USS PHILIP, to receive significant radiation on board ship. Exposures due to fallout from ROMEO were kept to a minimum, and were not of themselves serious. Unfortunately, in some cases personnel with relatively high exposures from BRAVO received a comparatively small additional exposure from ROMEO, but this was unavoidable. Fallout from ROMEO of relatively small intensity occurred over a large area including BIKINI, ENIWETOK and KWAJALEIN.

All shots caused exposure of some personnel due to the necessity of going into contaminated areas and decontamination of objects. The boat pool and helicopter personnel bore the brunt of exposure from contaminated areas. Personnel with low exposures were used for decontamination as much as practicable; nevertheless, the YAG personnel, in general, received relatively high exposures. This was due in large part to the necessity for using YAG personnel to supervise other personnel used to decontaminate and to maintain equipment on the YAGs.

Appendix 11a-V is a tabulation of accumulated exposures by units as of 12 May 1954. At the time of writing this report the final exposure records from Task Unit 7 have not been received, but the final records are expected to be not materially different from Appendix 11a-V. This appendix is nearly complete and reasonably accurate.

CTG 7.3, early in the operation, instituted a system requiring units to report weekly the number of persons with accumulated exposures in Roentgens as follows, 0-1, 1-2, 2-3, 3-4, 4-5, 5-6, 6-7, 7-7.8, over 7.8. Later CJTF SEVEN required reports of the number of persons with accumulated exposures, as of four days after each shot, in Roentgens as follows, 0-2.5, 2.5-3.9, 3.9-7.8, over 7.8. This necessitated two types of exposure reports from TG 7.3 units.

Operation CASTLE is the first instance of manned ships remaining in significantly radioactive waters continuously for days. This procedure was necessary to accomplish CASTLE missions in a reasonable time. It was found that ships could stay indefinitely in water where radioactive intensity a few feet above the surface was 2 mr/hr. The salt water systems, such as evaporators, condensers, fire main, etc., and in some cases the hull, became somewhat contaminated, but not to such a degree as to, in itself, expose any person to more than 0.3 R per week. The highest salt water system contamination reported was 100 mr per hour on the exterior surface of an auxiliary condenser of the CURTISS; the intensity decreased rapidly with distance from the condenser, so that a person standing watches in the same compartment as this condenser received less than 0.3 R per week. Ships were sent into contaminated water areas where the intensity a few feet above the surface was much greater than 2 mr/hr. In one case the water reading was as high as 300 mr/hr and the ship remained for a few hours without receiving any persistent contamination of even moderate degree. Sending ships into contaminated water was done only to accomplish important missions and for the shortest possible time. Some hulls apparently were much more readily contaminated than others. Sending a ship into uncontaminated water for a few hours after such exposure seemed to have very little effect on the contamination picked up in the salt water systems, and a stay of several days in uncontaminated water decreased contamination more than natural radioactive decay. Fresh water distilled from contaminated water was found to be non-radioactive in all cases, even when, in one case, distilled from water reading 30 mr/hr a few feet above the surface.

2. Conclusions

a. Operation CASTLE forcibly demonstrated the serious radiological contamination, and attendant personnel hazards, resulting from fallout following a nuclear ground burst, not only within a few miles from ground zero, but also many miles distant.

b. With minor exceptions, the radiological safety program was planned and carried out satisfactorily.

c. Presently prescribed methods of decontamination of ships and personnel are generally effective, but subject to improvement.

d. Ships normally need not be withdrawn from slightly contaminated water for fear of excessive contamination of salt water systems, nor for fear of contamination of distilled fresh water.

e. The number of film badges, together with personnel and facilities required for processing them, was insufficient.

f. Presently installed ship washdown systems are effective in preventing and reducing contamination of ships due to fall-out, but require improvement especially to rapidly remove relatively heavy, visible fallout particles.

g. Ships equipped with efficient water spray systems can continue to be manned, even after exposure to relatively heavy radioactive fallout, without permanent harmful effects to personnel.

h. Radiological defense measures, such as securing ventilation and closure of the ship, may require (especially in tropical waters) a reduction in the maximum speed available. If high speed is required, it may be necessary to accept a high radiological dosage for engineering personnel who require ventilation.

i. The danger of radiation burns and the difficulty of personnel decontamination may both be reduced by requiring that all hands wear complete clothing including hats.

j. The linen hose provided in the present washdown system for ships is unsatisfactory because it will not withstand sufficient high pressure and picks up considerable radiation contamination.

k. Nuclear explosions at the surface of the sea may cause large areas of the sea's surface as much as one hundred miles from the site of the explosion to become significantly radioactive. Much of the radioactivity may remain near the surface for a number of days, and diffusion may be slow. Inexperienced personnel on ships traversing these contaminated areas can easily mistake radiation from the water for fallout and turn on the washdown system, with harmful rather than beneficial results.

3. Recommendations

a. That research and development in radiological defense matters continue to receive high priority by BuShips and other defense agencies.

b. That improved ship washdown systems, capable of handling large volumes of water at high pressures, be developed and installed on all vessels participating in future operations.

c. That in future operations, adequate film badges, facilities and personnel be available to handle the photodosimetry program for the entire Task Force, without undue delay.

d. That, except as noted above, a radiological safety program similar to that of CASTLE, be planned for future operations.

e. That research and development continue in an effort to obtain a filter which will permit large volumes of air to enter engineering spaces without introduction of significant radiation hazards.

f. That Unit and Force Commanders be prepared to reduce speed and superheat requirements because of excessive temperatures in engineering spaces when the ventilation is shut down in preparation for or following atomic attack.

g. That Unit and Force Commanders be prepared to accept an increased radiological dosage for engineering personnel if high speeds are to be maintained preceeding or following an atomic attack.

h. That whenever danger of radioactive contamination exists, all hands be required to be fully dressed, including long-sleeved shirts and hats.

i. That in the design of future washdown equipment for ships, the linen hose be replaced by a stronger hose with a smoother outer surface.

j. Radsafe training should emphasize, among other things, methods of distinguishing fallout radiation from contaminated water radiation.

k. That future ship design take into consideration the following:

(1) Permanent washdown systems capable of immediate activation from the bridge, main control, or damage control central, including adequate fire main pump capacity.

(2) A rapid method of securing all unnecessary ventilation, such as a master switch.

(3) Air supply ducts for diesel engines to take air from outside the ship direct to the engines without contact with air inside the ship.

(4) Placing all fire main strainers inside ship.

l. That the helicopter decontamination equipment ("bathtub"), although adequate for the assigned task, be improved in design and construction as follows:

(1) Reduce the size of the "bathtub". It is only necessary for the canvas tub to extend a short distance beyond the

circle made by the rotor blades.

(2) Construct the tub of some waterproof or impermeable material. Preservative applied to canvas wears off, leaving spots that are easily contaminated and difficult to decontaminate.

(3) Devise a method of securing the underside of the tub to the deck to prevent the canvas from billowing up due to rotor downwash.

(4) Construct sides of the tub so they are inflatable for ease of installation and to enable aircraft to be pushed out of tub instead of having to fly out.

(5) Provide recirculating pump instead of P-500 to raise fresh water to flight deck. Lack of constant pressure from P-500 pump caused delays in helicopter decontamination.

m. That coveralls with caps and rubber gloves and boots rather than waterproof suits be used for decontamination in hot climates.

n. That in future operations, where practicable, a BuShips representative test washdown equipment of ships with low fire main capacity prior departure from CONUS.

o. That, for future operations, radiological safety training be accomplished essentially as in CASTLE.

p. That Radiological Safety annexes in future operations carry a classification no higher than Confidential and be given a wider distribution than the Operation Plan itself; and that unclassified radsafe instructions and information be distributed widely to personnel of all units.

q. That, in future operations, the Task Force and the Naval Task Group use a common system for accumulated exposure reports.

Part 11b - Radiac Instruments

1. Discussion

In preparation for CASTLE, BuShips instituted a program to insure that all ships assigned to the operation would have on board 100% allowance of all radiac equipment. This program was monitored by CTG 7.3 staff officers, and was successful except that CP-95/PD's were not available. In addition, CTG 7.3 was assigned a pool of radiac instruments for use and loan to TG 7.3 units as necessary.

As a result of use by all ships, the following evaluation of radiac instruments is made:

a. Most high range survey meters were either AN/PDR-18A's or AN/PDR-18B's. These instruments were found to be reliable and very satisfactory.

b. Most low range survey meters were AN/PDR-27's, AN/PDR-27C's or AN/PDR-27D's. These instruments were also found to be reliable and very satisfactory.

c. Portable alpha detection instruments available were of doubtful reliability. No instances of alpha contamination were encountered.

d. The usual proportion (about 15%) of pocket dosimeters would not hold a charge.

e. Considerable difficulty was experienced by some units with PP/354/PD type dosimeter chargers; they are difficult to control, and the charging of dosimeters is awkward and slow. The PP-311/PD type dosimeter chargers operated very satisfactorily, but were available to only a few ships.

All film badge dosimetry was done by Task Unit 7 of CTG 7.1. Ships' standard naval film badges were not used because they were too old for reliability in some cases, and were not calibrated for the development procedure and equipment used by Task Group 7.1.

Jury rig water monitoring devices were used in IVY. In CASTLE much greater water contamination was encountered than in IVY and the situation was thoroughly monitored by the use of normal radiac instruments. It was not found necessary to use special water monitoring devices. There are indications that the special water monitoring radiac instrumentation devised for IVY would have been unreliable after initial exposure to radiological contamination.

During CASTLE, a large number of batteries were found to be "dead" when brought out of storage, though placed in cold storage. It is possible they were "dead" before being placed in storage. In addition, a large number of batteries lasted a shorter time than is normally expected.

Inventories of spare batteries by supply department personnel proved to be inaccurate because these personnel were not familiar with the similarities of different type batteries.

Three radiation sources, of magnitude about 7500, 250 and 24 millicuries, were assigned to the Naval Task Group for CASTLE. Only the 24 mc source was used since it met the specifications of instruction books for calibration of all survey instruments used by TG 7.3. The larger sources are not well adapted to shipboard use, and their handling, transportation and storage presented unnecessary hazards.

Radiac instruments brought to the radiac instrument repair center for repair usually had no failure report card or equipment history card attached. Such information would have enabled repair personnel to locate defects of the instruments more quickly.

2. Conclusions

a. The AN/PDR-27 type instrument for low range (0-500 mr/hr) is a reliable and rugged instrument as proved by its excellent performance throughout CASTLE.

b. The AN/PDR-18 type instrument for high range (0 to 500 R/hr) was as dependable and accurate as any previous type of high range instrument, and is more easily maintained.

c. Batteries continued to be the cause of most radiac instrument breakdowns due to over age when drawn from supply.

d. No reliable alpha counters were available other than those available for use by the laboratories of TG 7.1.

e. Attempts to stock batteries, spare parts, etc. for more than a few reliable, standard types of instruments proved futile, due to space and limited facilities for repair.

f. Except for experimental use, only accepted, standard types of instruments should be employed in future operations.

g. No special water monitoring devices are necessary, except for purely scientific purposes, in an operation of the CASTLE type.

3. Recommendations

a. That for future operations, and except for experimental use, only the AN/PDR-27 and AN/PDR-18 type instruments and standard newer types be used generally.

b. That reliable alpha counters, if developed, be available in limited numbers in case unexpected alpha producing fallout is encountered.

c. That great care be taken through supply channels to insure that only reasonably fresh batteries are shipped and stocked for use in the forward area in future operations.

d. That all old, obsolescent radiac instruments be replaced with AN/PDR-27 and 18 types as rapidly as the latter are available.

e. That all units be directed to use Failure Report Cards and Equipment History Cards with survey instruments in future operations.

f. That each ship carry not less than 100% spare batteries for radiac instruments in future operations.

g. That in future operations only one radiation source be taken on board ship by the Naval Task Group for calibration of survey instruments. This source should have a magnitude of around 50 millicuries and not less than 20 millicuries.

h. That steps be taken to insure accuracy of storage battery inventories in future operations.

i. That insofar as practicable, all ships report for future operations with 100% allowance of all radiac equipment on board.

Part IIc - AEC World Wide Fallout Monitoring Program

1. Discussion

Patrol Squadron Twenty-Nine participated in the AEC World Wide Fallout Monitoring Program during CASTLE. CinCPacFlt letter serial 00113 dated 11 February 1954 promulgated the details of this program and the extent to which Task Group 7.3 forces were to participate. Essentially the requirements were to fly three designated patterns over selected atolls when requested by CJTF SEVEN both before and after each shot.

The three patterns were as follows:

ABLE	MILES	TOTAL	BAKER	MILES	TOTAL	CHARLIE	MILES	TOTAL
KWAJALEIN	90		KWAJ	50		KWAJ	350	
LAE	38	128	NAMU	50	100	KUSAIE	145	495
UJAE	66	194	AILINGLAPLAP	114	214	PINGELAP	62	557
WOTHO	95	289	NAMORIK	73	287	MOKIL	95	652
BIKINI	67	356	EBON	68	355	PONAPE	240	892
AILINGINAE	25	381	KILI	35	390	UJELANG	414	1306
RONGELAP	39	420	JALUIT	148	538			
RONGERIK	217	637	MILI	65	603			
TAONGI	110	747	ARNO	33	636			
BIKAR	111	858	MAJURO	68	704			
UTIRIK	13	871	AUR	33	737			
TAKA	53	924	MALOELAP	64	801			
AILUK	26	950	ERIKUB	20	821			
JEMO	28	978	WOTJE	146	967			
LIKIEP	108	1086						

Prior to BRAVO one flight was flown, with a project representative on board, over the old IVY site for the purpose of determining the proper location of the scintillation meter within the aircraft. Information concerning the flight patterns, flight altitude, operation of the equipment and required reports were provided by the AEC representatives. Initially the entire atoll was monitored and the maximum instrument reading was recorded. Later only one specific island out of each atoll was monitored.

CTU 7.3.3 initially had available a total of only two scintillation meters (type TH 3.B) for the purpose of conducting survey flights prior to UNION. This meant that only two aircraft could conduct a survey flight at any one time and that no stand-by instruments were available when two flights were air borne. If instrument failure had occured in flight the entire mission would have had to been aborted. Additional instruments later were made available so that CTU 7.3.3 had a total of seven scientillation meters for UNION, and for all subsequent shots. It is desirable that two scientillation meters be made available for each flight required to be air borne. This would prevent aborting a flight for reason of instrument failure.

In addition to the three established patterns ABLE, BAKER and CHARLIE, one special survey flight was flown on March 6 monitoring all the major GILBERT Islands. This was approved by the British Authorities and the results were forwarded to U.S. Naval Attache, London, for the information of the British Government.

The atoll survey flights initially presented a problem in as much as there were no suitable charts available. Hydrographic charts were few and generally unsuitable for cockpit use due to their size. Later a number of atoll photo packets were made. These consisted of 27 different atoll photographic reproductions of 8 x 10 size suitable for cockpit use.

A total of 27 survey flights were conducted with the flight time amounting to 197.5 hours. This is an appreciably greater effort than originally anticipated and was due, in part, to repeat flights occasioned by shot delays.

The requirement to carry out this important program, in addition to necessary searches of the greatly enlarged danger area, at times overtaxed the capabilities of VP-29. In view of the pattern lengths and the relatively light aircraft loads, the flights in support of this program could have been made by other types of aircraft (PBM-5A or UF) had such been available.

2. Conclusions

a. Patrol Squadron TWENTY-NINE provided satisfactory support to the AEC World Wide Fallout Monitoring program during CASTLE.

b. A greater effort was devoted to this project than was originally anticipated, due to added requirements as well as the necessity for re-runs resulting from delayed shots.

c. The airborne monitoring missions do not require a P2V type aircraft. Any aircraft with the required range could be utilized. The pattern lengths were: ABLE 1078 NM, BAKER 972 NM and CHARLIE 1306 NM.

3. Recommendations

a. That for future operations consideration be given to utilizing PBM-5A or UF aircraft, rather than security aircraft, to perform these missions.

b. That every effort be made in advance to ascertain the full requirements of this program in order that adequate forces may be provided to carry it out.

APPENDIX 11a-I

Average topside radioactive intensities (in mr per hour) of Task Group 7.3 ships at various times following BRAVO.

Gamma Only (Pg J-8)

DATE	LOCAL TIME	CURTISS	ESTES	AINS-WORTH	BELLE GROVE	COCOPA	APACHE	SIOUX	PC 1546	BAIROKO	PHILIP	GYPS
MAR												
1	0900	8	400(e)	-	-	-	-	-	-	500	750	-
	1000	5	200(e)	-	-	-	-	-	-	500	265	-
	1100	3	150(e)	-	-	-	-	-	-	500	196	-
	1200	2	100	-	4	-	-	-	1	350	145	-
	1300	5	100	1	5	5	3	4	3	300	147	-
	1400	18	110	2	12	10	7	8	6	240	138	7
	1500	25	120	10	20	14	2	9	15	200	134	30
	1600	45	140	16	35	18	12	10	21	170	180	200
	1700	55	120	22	75	20	50	22	25	140	225	230
	1800	50	120	19	150	75	17	50	80	200	262	250
	1900	40	120	20	190	75	20	34	90	180	194	200
	2000	37	120	20	300	110	30	15	85	130	193	150
2	0000	30	120	20	80	75	30	40	80	160	188	130
	0400	25	120	20	60	70	30	30	50	145	156	110
	0800	20	30	20	60	30	25	12	40	134	111	80
	1200	15	50	20	50	20	10	10	30	108	78	45
	1600	10	30	12	50	20	10	9	20	36	60	40
	2000	10	20	10	20	18	10	7	15	30	47	35
3	0000	9	20	8	20	15	8	6	14	27	39	35
	0400	8	18	7	15	12	3	6	13	25	41	35
	0800	7	16	6	12	7	3	5	12	22	34	25
4	0800	3.2	7	5	8	5	2	4	6	14	17	20
5	0800	1.2	4	4	7	3	2	4	3	9	8	14
6	0800	1	4	3	5	2	2	4	2	6	7	12
7	0800	1	2.7	2	3	2	1	[illegible]	1	4	5	10
8	0800	1	2.1	1.5	2	1.5	1	4	1	3	4	8

All manned ships other than those listed in this table received negligible contamination.

NOTE: (e) - estimated

ROMEO

APPENDIX 11a-II

TABULATION OF AVERAGE TOPSIDE RADIOACTIVE INTENSITIES OF TASK GROUP 7 SHIPS AT VARIOUS TIMES FOLLOWING ROMEO

DATE	TIME	ESTES	BAIROKO	BELLE GROVE	EPPERSON	RENSHAW	PHILIP	COCOPA	MENDER	APACHE	SIOUX	MOLALA	LST 551	AINSWORTH
27 Mar.	1400						.4							
	1500						1.6			.2			.1	
	1600				.5		2.6			20			2.1	
	1700				1.0		2.5			1.2			2.5	
	1800				1.5		2.5			1.8			2.9	
	1900				25		2.4			.9			2.8	
	2000				10		1.9			.6			2.8	
28 Mar.	0000				3.5		1.8			.6	1	2	1.1	
	0400				4.0		.7			.35	2	10	1.1	
	0800				15		1.3			.3	8	13	.3	
	1200				7		.5			28	16	9	.7	
	1600	.3		.3	5		.7		.3	42	16	7	.8	.3
	2000	2	1	4	4.5	.2	.8		1.5	20	30	5.4	2.7	1.5
29 Mar.	0000	12	25	20	3	20	12	25	27	25	18	5	15	24
	0400	10	25	10	3.5	10	21	20	20	20	18	3.5	25	10
	0800	8	25	11	8	9	19	10	18	20	30	2	22	22
30 Mar.	0800	8.7	11	14	5	7	11	5	8	10	3	2	10	7
31 Mar.	0800	6.3	7	8	3	3	8.3	5	7	8	4	2	7.5	5
1 Apr.	0800	3.2	6	5	1	2.5	5.8	3	5	6	4	1	5	4
2 Apr.	0800	2.5	5	4	.5	1.5	4.6	3	4	4	3	1	2.8	2.5
3 Apr.	0800	2.5	3	3	.2	1	3.3		3	3	2	1	2	1.5

All manned ships other than those listed in this table received insignificant contamination.

APPENDIX 11a-III

Contamination of ships at about time of release from Operation CASTLE.

SHIP	HIGHEST mr/hr	AVERAGE mr/hr	DATE OF REPORT	DATE OF RELEASE
ESTES	1.5	1.0	14 May	14 May
CURTISS	1.8		21 May	14 May
BAIROKO	2.5		21 May	17 May
BELLE GROVE	6		16 May	18 May
AINSWORTH	.04	.01	20 May	19 May
EPPERSON	3	Less than 1	14 May	15 May
PHILIP	1.1	.6	14 May	15 May
NICHOLAS	0	0	14 May	15 May
RENSHAW	.4	.06	14 May	15 May
PC 1546	.3		7 May	9 May
LENDER	1.5	1.0	16 May	16 May
COCOPA	20	Less than 1	Est. 16 May	17 May
SIOUX	15	1	16 May	17 May
APACHE	30	.2	14 May	16 May
TAWAKONI	.2		18 May	11 May
MOLALA	17	1	16 May	26 May
SHEA	1.2	.2	14 May	3 May
RECLAIMER		Less than 1	Est. 16 May	7 May
LST 551	0	0	16 May	16 May
LST 762			Contaminated after being released from TG 7.3 enroute Pearl	4 May
LST 1157		Less than 1	Est. 16 May	17 May
LCU 637	200	6	16 May	14 May
LCU 638	110	35	15 May	15 May
LCU 1224	130	35	15 May	15 May
LCU 1225	110	30	15 May	15 May
LCU 1343	35	12	16 May	14 May
YFN 934	0	0	16 May	13 May
YC 10[illegible]1		30	16 May	15 May
YOV 9	90		18 May	11 May
YO 120	0	0	16 May	15 May
YOG 61	0	0	16 May	1[illegible] May
YOGN 82	0	0	16 May	16 May

APPENDIX 11a-IV

RADIOLOGICAL CONTAMINATION OF VP-29 PLANES AS OF 18 MAY 1954

PLANE NUMBER	HIGHEST GAMMA (MR/HR)	HIGHEST BETA+ GAMMA (MR/HR)	AVERAGE GAMMA (MR/HR)	AVERAGE BETA + GAMMA (MR/HR)
126544	1.4	4.2	.8	1.5
126534	1.5	3	.7	1.4
126537	.4	1.5	.2	.6
126539	0	1	0	.6
126541	1.5	1.9	.2	.7
126543	.6	1.3	.4	.6
126532	4.7	4.9	2.5	1.3
126535	.3	1	.16	.4
126538	.9	2	.4	.7
126540	.2	1.2	.15	.5
126542	.2	1.5	.15	.4
126522	.35	3	.15	1.5

APPENDIX 11c-V

Tabulation of Accumulated Radiological Exposures of Task Group 7.3 Personnel by ships and units as of 12 May 1954

UNIT	0.0 to 0.999	1.0 to 1.999	2.0 to 2.999	3.0 to 3.999	4.0 to 4.999	5.0 to 5.999	6.0 to 6.999	7.0 to 7.8	Over 7.8
	EXPOSURE IN ROENTGENS								
TG 7.3 STAFF	10	47							
USS BAIROKO	412	238	67	50	67	8	1		
HMR-362		73	10	15	11	2			
USS CURTISS	682								
VP 29	388								
USS ESTES	116	376	124	17	11	7			
USS BELLE GROVE	4	272	38	20					
TG 7.3 BOAT POOL	34	77	50	31	13	6	1	1	4
*USS LST 762	74	26	10	2					
USS LST 551	103								
USS LST 1157	124								
USS EPPERSON	198	80	7						
USS NICHOLAS	267		1						
USS RENSHAW	221	30	6						
USS PHILIP		36	103	87	32	2	1		
*USS SHEA	299								
*USS PC 1546	33	13	1						
*USS GYPSY	1	32	29	1					
*USS MENDER	63	9							
*USS RECLAIMER	93								
USS MOLALA	28	35	14	1	3	3		1	
USS APACHE	65	12							
USS SIOUX	15	60	5						
USS TAWAKONI	76	1							
USS COCOPA	13	42	15	8					
USNS AINSWORTH	157	28							
YAG 39	12	5	6	5	4	1	5	5	8
YAG 40	7	4	9	7	14	6	1	2	1

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UNIT	EXPOSURE IN ROENTGENS 0.0 to 0.999	1.0 to 1.999	2.0 to 2.999	3.0 to 3.999	4.0 to 4.999	5.0 to 5.999	6.0 to 6.999	7.0 to 7.8	Over 7.8
TG 7.3 UDU	22								
PROJ. 6.4 AIRCRAFT	8								
PROJ. 1.4 AIRCRAFT	8								
VC-3	44								
TOTAL	3564	1496	495	244	15[illegible]	35	9	9	13
Per Cent (Total)	59.34	24.77	8.20	4.04	2.57	0.5[illegible]	0.15	0.15	0.22

* Detached

Part 16 - Medical

1. Discussion

During Operation CASTLE, the health of Task Group 7.3 personnel, in general, was very good. The medical and surgical care and treatment of naval personnel was largely accomplished in a very creditable manner by the medical departments of the ships of the Task Group. Satisfactory sanitary conditions aboard all vessels and on recreation islands contributed to a low incidence of sickness and disease. No serious epidemics or major catastrophes occurred.

Operational conditions made it difficult to run a Medical and Dental Guard on a rotating basis, either at BIKINI or at ENIWETOK. Adequate medical and dental care nevertheless was available to all personnel. A Medical Guard was set up whenever two or more ships having medical officers were anchored in a lagoon at the same time. If the ship having the Medical Guard had a dental officer aboard, it was designated as having the Dental Guard as well. When a ship having the Medical Guard was far removed from the other ships in a lagoon, there was a tendency on the part of the smaller ships to send patients to the nearest ship having a medical officer which was not necessarily to the guardship. A solution satisfactory to all concerned was accomplished by not scheduling for the Medical Guard any ship which was not in the vicinity of the majority of ships.

Complicated medical problems were referred to the medical officers of other ships, and on occasion to the Army Dispensary, ENIWETOK. At the request of the staff medical officer a qualified general surgeon was ordered to the USS ESTES (AGC-12). With the large number of personnel and ships involved in the navy task group, BuMed considered the request not only reasonable but desirable. A flight surgeon who was also a general surgeon could have been ordered to the CVE had the request been submitted earlier. This would have the advantage of getting the surgeon via helicopter to the scene of a disaster in a minimum of time. Eye refractions were performed by the flight surgeon on the USS BAIROKO (CVE-115) and at the Army Dispensary, ENIWETOK. One officer was flown to U.S. Naval Dispensary, KWAJALEIN for special roentgenological examination; while another, a ship's commanding officer was flown to Tripler Army Hospital, OAHU, T.H. for a complete urological examination. Both individuals, considered critical to the operation, were returned to duty in a minimum of time.

The Army Dispensary on ENIWETOK treated those naval personnel who were billeted ashore, and who required emergency treatment while ashore on liberty, or who were transferred to them for treatment and/or evacuation. Naval personnel, who, in the opinion of appropriate medical authorities could not be returned to duty within fifteen (15) days, usually were transferred to the Army Dispensary, ENIWETOK, where they were held and treated until air evacuation was arranged by CTG 7.2. A small number of naval personnel who had been transferred originally to the Army Dispensary, ENIWETOK for treatment only, required evacuation as well. In these instances some delay in evacuation was experienced because orders -

authorizing the transfer of these individuals to Tripler Army Hospital had to be requested by the Army Dispensary from the individual's ship or activity. In one particular emergency case it became necessary for the Army Dispensary to write the transfer orders. All told, twenty-eight (28) naval personnel were evacuated to Tripler Army Hospital. It was the observation of the dental officer of the Army Dispensary, ENIWETOK, that a large number of naval personnel, in particular those on the smaller ships, arrived in the forward area requiring dental treatment. Holmes and Narver Medical Departments at both PARRY and ENYWAN Islands gave medical and dental treatment to the few TG 7.3 persons present needing such.

Three (3) deaths occurred; one from a myocardial infarction; the second from an accident, the victim being crushed between an LCM and an anchor; and the third from drowning. The only other serious accident was a crushing spinal injury producing paraplegia, which occurred when a hatch fell on the individual. In addition to the requirements contained in Chapter 17, Manual of the Medical Department, relative to care of the dead, a Territory of Hawaii Death Certificate was required. Bodies of the dead were kept refrigerated in the supine position until transfer could be effected to the Mortuary Officer, ENIWETOK who arranged for transportation to KWAJALEIN or Tripler Army Hospital. Human remains pouches, obtained from the Army Supply Depot, ENIWETOK, proved to be a convenient means for storage and transportation of the dead. The method used by the Army to transport the dead is to place the body in a human remains pouch; place the latter in a regulation coffin from which the lining has been removed; fill the coffin with ice; place coffin in a coffin box and transport the box by air to Tripler Army Hospital. This method was used in transporting the body of one of the naval personnel and appeared to be both expensive and unnecessary.

The Maximum Permissible Exposure (MPE) established for personnel of Operation CASTLE was 3.9 roentgens (gamma only) calculated on the basis of 0.3 roentgens (gamma only) per week for a thirteen (13) week period. Provided no previous over-exposure remained, this MPE of 3.9 roentgens could have been acquired without regard to the individuals past radiation history. This MPE was considered further augmented by 0.3 roentgens per week for each week in excess of thirteen (13) weeks of the operational period. All exposure to external gamma radiation was regarded as total irradiation.

Following BRAVO, as a result of the relatively heavy radioactive fall-out on nearly all ships, the necessary decontamination procedures following, and the radiation received by helicopter and boat pool personnel in support of the Scientific Task Group, a large proportion of the personnel of Task Group 7.3 were exposed to radiation in varying degrees.

A relatively high percentage of the personnel of the following groups received exposures approaching or exceeding 3.9 roentgens: entire crew of the USS PHILIP, flight deck crew of the USS BAIROKO, helicopter pilots and plane captains, and boat operating personnel of Task Group 7.3 Boat Pool. On the recommendation of CTG 7.3, CJTF SEVEN increased the Maximum Permissible Exposure for all personnel of these groups to 7.8 roentgens. During the course of the operation the MPE of other critical personnel was increased to 7.8 roentgens by CJTF SEVEN on the recommendation of CTG 7.3. Every effort was made to assign personnel with high exposures to activities requiring minimum or no exposure. Following BRAVO, the USS PHILIP was employed for the remainder of the operation at locations other than near the shot atoll at shot times whenever possible. This was not practicable in the case of the USS BAIROKO but steps were taken to station BAIROKO, insofar as possible, in locations where the probability of receiving additional significant fall-out was reduced.

In a letter to the Commander in Chief, U. S. Pacific Fleet, dated 3 May 1954, The Chief of Naval Operations (OP-362D/em Ser 0328P36), in effect, stated that naval personnel may accumulate an integrated external radiation exposure of 30 roentgens (gamma only) in a period of two years or less provided: (1) no more than 15 roentgens are accumulated in any three consecutive month periods, (2) personnel immediately thereafter are not assigned to billets requiring routine exposure to ionizing radiation (3) upon accumulating an integrated exposure of 30 roentgens, they will be removed from any further exposure to ionizing radiation until their total exposure of 30 roentgens has been integrated over a two year period and (4) that individual personnel exposure records are diligently maintained on all individuals. These Maximum Permissible exposures for naval personnel are considered realistic for operations of this type. Had these MPEs been adopted initially the personnel replacement program would not have been necessary, and the considerable time and effort expended in requesting and justifying increases in the MPEs in particular individuals, would have been eliminated. Furthermore, these higher MPEs would reassure personnel and decrease their personal concern upon receiving lesser dosages.

The film badges of three (3) men of an LCM crew indicated a dosage of approximately 9CR. Thorough investigation failed to reveal how these three (3) men could have received this much radiation; however, they were transferred to Naval Station, KWAJALEIN and later to Tripler Army Hospital, OAHU, T.H. where after complete clinical and laboratory studies, which were essentially negative, they were discharged to duty. Sixteen (16) personnel on the USS BAIROKO (CVE-115) and twenty-one (21) personnel of USS PHILIP (DDE-498) received small skin lesions resembling burns which circumstantial evidence indicated were due to radioactive fall-out particles from BRAVO. Present indications point to an uncomplicated healing of these burns.

The problems of atomic medicine along with other medical problems peculiar to this operation were discussed with each of the ship's medical departments. Radiological physical examinations were not a requirement for participation in Operation CASTLE.

Appendix 11a – V shows the accumulated radiological dosages of personnel of Task Group 7.3 as of 12 May 1954. No significant increases in dosages occurred following that date.

2. Conclusions

a. The health of Task Group 7.3 personnel was, in general, very good.

b. Medical facilities, supplies and personnel in the forward area were adequate. The services of a general surgeon on one of the major naval ships was highly desirable.

c. The Medical Guard as set up worked satisfactorily except when a ship having same was far removed from the majority of the ships.

d. The procedure for evacuation of personnel for medical reasons, was, in general, satisfactory. In a few instances delays resulted when a ship had to be contacted for orders authorizing the evacuation of its personnel.

e. The procedure for transporting human remains from the ENIWETOK/BIKINI area should be reviewed.

f. Radiological hazards to personnel were significant. However, permanent damages due to such are not anticipated.

g. Radiological skin burns can result from fall-out particles, especially if exposed personnel are not quickly sent through a decontamination facility.

h. The initial MPLs of naval personnel in some employment groups (helicopter pilots and boat pool operating personnel) were too low.

i. The Maximum Permissible Exposures for naval personnel set forth in the letter of The Chief of Naval Operations (OP-362D/em Ser 0328P36) are realistic for operations of this type, and, if adopted, a personnel replacement program in future operations would probably not be necessary.

3. Recommendations

a. That radiological physical examinations not be a requirement for participation by naval personnel in future operations, except for those relatively few individuals who will remain indefinitely in assignments where radiological hazards are present.

b. That necessary dental work required by naval personnel be completed prior to arrival in the forward area.

c. That a Medical Guard be set up whenever two or more ships with medical officers are present in the same vicinity in a lagoon and that a ship having a medical officer which is in the same lagoon but far removed from the majority of ships not be scheduled for the Medical Guard. If a ship having the Medical Guard has a dental officer aboard it should also be assigned the Dental Guard.

d. That an individual transferred to the Army Dispensary, ENIWETOK for treatment should have included in his orders, a directive, to be put into effect by the Army Dispensary should it be necessary, ordering the officer or enlisted man to Tripler Army

Hospital, OAHU, T. H.

e. That the present procedure for transporting human remains from the ENIWETOK/BIKINI area be re-evaluated from the standpoint of expenditure of materials, weight (by air) and destination. The feasibility of sending a body iced in a human remains pouch direct to Tripler Army Hospital, or via KWAJALEIN where it can be refrigerated and re-iced before departure, should be given careful consideration.

f. That one of the ship's medical officers, preferrably the flight surgeon of the CVE, be a qualified general surgeon who may be flown by helicopter to other ships of the task group as, and if, needed.

g. That the Maximum Permissible Exposures set forth in Chief of Naval Operations letter (OP-362D/em Ser 0328P36) of 3 May 1954 be adopted for naval personnel in future operations.

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TAB "K"

BRAVO EVENT

Alert advisories on the scheduled detonation for BRAVO (010645M March) were issued on B-5 days to the Chairman AEC, C/S Army, and CINCPACFLT. Prior to shot time, weather summaries for B-3 and B-2 days indicated that the most favorable condition for accepted criteria for shot time from a weather/radsafe point of view was prevailing and was forecast to hold through scheduled shot time. The wind conditions indicated fan-shaped fall-out areas in the northeast and northwest quadrants from GZ.

Arrangements had been completed with TG 7.3 units relative to the type of search pattern to be performed in the sweeps for the protection of transient shipping. As previously designated, sweeps were to be made to 800 NM in the significant sector on shot day minus two days to identify, or at least contact, any shipping within, or likely to move within, the forecast fall-out area. The search pattern was to be rectangular, the long axis centered on a bearing line to be determined on the basis of the forecast fall-out area. One aircraft was to be used at low level on an outbound and inbound track paralleling the forecast central bearing line, with the two tracks spaced 50 NM away from the center line. Total search coverage, considering radar range, for the 800 NM pattern was expected to be an area 200 NM wide and 800 NM long. On Shot day minus one day, sweeps were to be made to 600 NM in the significant sector to identify or contact shipping and to divert shipping as necessary from a sector area to be designated on the basis of the forecast fall-out area. The 600 NM search pattern was to be triangular in shape, apex on GZ and centered on a significant bearing line based on the forecast fall-out area. The base of the triangular pattern was planned to be 100 NM wide. One aircraft was planned to fly the pattern, outbound on a long side of the triangular pattern, across the base, and inbound on the opposite long side of the pattern. Total search coverage, considering radar range, for the 600 NM pattern was expected to be a trapazoidal area approximately 200 NM wide on one base, 100 NM wide at the other and 600 NM long. Sweeps on shot day itself were planned to be specifically described in the event such searches became necessary. Three BRAVO sweeps were performed in accordance with the above. In addition, CINCPACFLT had been requested to route shipping in the area so as to be outside a 500 NM sector centered on GZ with limiting true bearings of 225 clockwise to 90 degrees from H to H plus 24 hours. In accordance with this plan, CINCPACFLT on 20 February advised COMNAVFORMARIANAS and COMHAWSEAFRON to the effect that shortly before each CASTLE detonation, CJTF SEVEN would issue message advisories concerning the anticipated radiological impact on air and surface routes and would include recommendations relative to closure of routes, that during the two days preceding each shot, TG 7.3 search aircraft would make reconnaissance flights in the significant fall-out quadrant out to 600 NM to clear itinerant shipping from the predicted cloud passage area, and that on the basis of this information, to implement action to divert ships from possible hazardous areas and to assist the mission of the TG 7.3 aircraft as practicable. No transient shipping was reported on the B-2 day P2V sweep centered on a significant forecast cloud movement on true bearing of 300° out to 800 miles from GZ. The B-1 day search by P2V out to 375 miles on a forecast significant cloud movement on a true bearing of 330° disclosed no transient shipping except the General Patrick, whose course and speed would take her outside the hazardous area by shot time.

By the morning of B-1 day, the wind patterns (forecast and actual) were favorable but the trend of the observed resultant wind patterns was toward an unfavorable or marginal condition. Following the 1100M, B-1 Command Briefing, the routine H-18 hour advisory to CINCPACFLT indicated forecast 72-hour air particle trajectories for ten and fifty thousand feet, no significant fall-out forecast for populated Marshall Islands, and no safety problems on air or surface routes except surface routes between 275° clockwise to 80° out to a radius of 450 NM with possible significant fall-out in this area. No known shipping was in the forecast fall-out area. The Surface RADEX was forecast for shot time to shot plus six hours to be a 30° sector to the west southwest and a narrow sector centered on 65° with an additional circular radex area around GZ of radius 15 miles. The Air RADEX from ten thousand feet and up (as well as forty thousand feet and up) included an area between true bearings of 285° clockwise to 70° from GZ. The H plus 1 hour RADEX was specified for a maximum distance of 18 NM; the H plus 6 hour was specified as six times the H plus 1 hour distance.

The British Sampling Unit on KWAJALEIN was advised at H minus 18 hours of the firm schedule for BRAVO, the forecast 72-hour air particle trajectories, the anticipated area for British operations and directed not to penetrate the Danger Area unless specifically authorized later to do so by CTG 7.4. The British Unit was advised that final scramble and routing instructions would be issued by CTG 7.4 at H plus 3 hours, and directed to file a flight plan through the Kwajalein Liaison Officer using this advisory as authority for BRAVO flights.

At the 1800M Command Briefing, the decision was made to continue on the previous decision to shoot, but to look at the complete weather/radsafe situation again at midnight, and to move the Control DDE from its position due west of GZ at 90 NM to a position on true bearing of 230°, 90 NM from GZ.

At approximately 2200M, CTG 7.4 was directed to set up the first cloud tracker (WB-29, Wilson 2) to search H plus 2 to H plus 14 hours from base to a three-hour racetrack holding pattern 50 NM west of GZ, thence to a sector centered on GZ, limiting true bearing 55 and 85 degrees to 500 NM.

At the midnight briefing, the forecast offered a less favorable condition in the lower levels (10,000 to 25,000 feet). Resultant winds at about 20,000 feet were forecast in the direction of RONGELAP and RONGERIK (see Incl 5); however, it was considered that the speeds and altitudes did not warrant a conclusion that significant quantities and levels of debris would be carried out so far. The decision to shoot was confirmed subject to a further weather/radsafe check at 0430M BRAVO Day. TARE Site was forecast to be well in the fall-out area and NAN Site to be in a fairly high intensity area. Since the B-1 day forecasts gave winds tending significantly from west southwest, a decision was made at the midnight briefing to search for shipping ahead of the cloud, i.e. centered on true bearing of 65° out to 600 NM, and to warn ships out of a 450 NM minimum radius. At approximately H-4 hours, the British Unit on KWAJALEIN was given the forecast H hour GZ winds.

At the 0430M briefing, no significant change had been observed in the latest winds except that the GZ observations were showing more northerly and westerly components in the lower levels than before. In view of this, the radsafe recommendation was made to move the task force ships radially further out from the minimum of 30 NM to a minimum of 50 NM from GZ in the southeast quadrant. This was done for the smaller and slower vessels, but the larger ships remained at 30 miles to maintain voice communication with the bunker firing party personnel on NAN and in order to maintain a capability for helicopter evacuation for this party. The resultant winds pointing at RONGERIK and RONGELAP were light and were not forecast to transport significant debris to these atolls. Search results, as well as other sources of information, relative to transient shipping being negative, the decision to shoot was confirmed. A post-shot analysis of the BRAVO fall-out pattern (by elliptical approximation) is included in Inclosure 11. Based on the midnight forecast, confirmed at 0430M, the Surface and Air RADEXES were modified as indicated in Inclosure 5.

At 0645M, 1 March 1954, BRAVO was detonated on the surface of a small sand spit between sites BAKER and CHARLIE without hazard to task force personnel. The bunker firing party reported in safe, but by 0715M the radiation levels were reported rising at the bunker. These levels continued to rise to about 25 r/hr. The firing party was considered to be in a reasonably safe position since the personnel were able to get into a well protected area deep in the bunker, reading approximately 35 mr/hr.

The overall cloud assumed a funnel shape with the stem a very small (approximately ten mile diameter) column underneath. The juncture of the lower stem with the funnel was at about 20,000 to 25,000 feet. The top of the funnel was at about the tropopause. Above the funnel an over-running lip formed apparently from splash-out at, and above the tropopause. At about H + 30 minutes visible particles were observed coming from the juncture of the stem with the upper funnel. The rain of visible particles moved out and up the sides of the funnel until an area was defined, the diameter of which was on the order of fifty miles. (For a further precise description of the cloud formation and evidence of the area of early falling particles, see the final report of Project 9.1 Cloud Photography.) The general appearance of the clouds for the remaining high yield CASTLE shots was similar to BRAVO with the exception that large volumes of the cloud below the large upper over-running lip appeared to be more of a white water aerosol than BRAVO.

The cloud tracking (by Wilson 2) during the morning on shot day indicated no contamination of consequence moving toward ENIWETOK or UJELANG at ten thousand feet, readings being on the order of 10 mr/hr maximum. Due to a misunderstanding, Wilson 2 was delayed by the Air Operations Center and over-stayed his time in the racetrack holding pattern. This resulted in a material delay in Wilson 2 starting his sector search upwind from GZ with the result that his search was apparently performed to the north and behind the major portion of the contamination responsible for the Marshall Island fall-out. A warning was relayed to Wilson 2 to expect a contaminated area about 200 NM east northeast of GZ on his upwind sector search. This was based on an abbreviated report from the BRAVO Day transient shipping search aircraft, reported to have encountered contamination and aborted at a point west of that location. During the upwind portion of the Wilson 2 mission, intensities were from 100 to 500 mr/hr maximum. (See Inclosure 6). Due to the abort of the first transient shipping search aircraft, another was requested to complete the mission. The exact coverage by these two aircraft was not determined until several days following BRAVO. From the logs, it appears that the first aircraft reached a position approximately 65 NM due east of GZ by 0950M only to abort due to contamination and return to base at KWAJALEIN. The second aircraft attempted to pick up the designated 65° search track, but encountered contamination at about 160 NM on a bearing approximately 85° from GZ. This aircraft moved out further east and eventually picked up the 65° search track 240 NM from GZ at 1533M. No contact was reported on the Fukuryu Maru, the Japanese fishing boat involved in BRAVO fall-out. Due to improper handling of a dispatch, the first P2Vs 0949M 1 March report of 500 to 1000 mr/hr at 238 NM on 86° true from ENIWETOK at 1000 feet did not reach RadSafe until 6 March.

At about 0800M, due to the arrival of early fall-out, all ships were directed by CTG 7.3 to open to 50 NM from GZ on a southerly course at best speed using wash-down systems as necessary. Previously, the slower and smaller ships had been moved out, however, operational problems dictated closer positions for some of the larger vessels. Of primary concern was the maintenance of communications with the bunker firing party and the ability to evacuate the party by helicopter if necessary. After stabilization of the bunker radiation field (with acceptable levels inside the bunker) this requirement became relatively less important.

At about H plus 4 hours, CTG 7.4 was directed to set up the second cloud tracker (Wilson 3) for H plus 12 to H plus 24 hours search at 10,000 feet in a sector centered on RONGERIK with limiting true bearings 50° and 80° to 500 NM, thence to 17 N, 163E to base. Wilson 3 was authorized to shift his last turning point if necessary to accomplish his mission within range capabilities. Wilson 3 was advised to expect contamination approximately midway through the sector portion of his mission. The vectored route following the sector search was selected in accordance with the forecast cloud travel toward the north and east and was specified to verify forecasts and to evaluate the impact of contamination on the air and surface routes through Wake Island.

At approximately H plus 5 hours confirmation was given to previous verbal authority for penetration of the Danger Area by the British Unit.

Confirmation of the Wilson 2 survey between ENIWETOK and GZ was available in a report from the ENIWETOK monitoring system which reported readings, in rain, at 1745M on shot day of 4 mr/hr on FRED and 3 mr/hr on ELMER. Subsequent reports were in good agreement, maximums reaching 10-15 mr/hr during the night of 1 and 2 March.

During the afternoon of shot day it was decided to return the major ships to ENIWETOK for re-grouping of personnel. Radsafe recommended that no ships enter the lagoon prior to 2 March and that water sampling (lagoon, drinking and salt systems) be carried on continuously during re-entry of the BIKINI lagoon on plus one day and thereafter. Subsequent to 2 March, lagoon contamination proved more an operational nuisance than a hazard. Water intakes and evaporators slowly built up activity, but stabilized with routine decontamination actions by about 10 March, however, salt water systems, such as heads and salt water pipe fittings, required flushing occasionally to maintain acceptable levels. (See Tab J.)

A report was received about 2100M on B Day that the HASL NYKOPO instrument in the hands of the weather detachment on RONGERIK had gone "off scale." These instruments had a full scale reading of 100 mr/hr. No higher scale instruments were available at RONGERIK. The off-scale report was not viewed with concern since task force ships were experiencing readings of more than 100 mr/hr (the BAIROKO going as high as 500 mr/hr on the flight deck). Considering the distance (133 NM) and a cloud tracker at about 1945M, 1 March reporting of zero contamination over RONGERIK, it was generally believed that RONGERIK and the task force ships were caught in a general east-west pattern of finely divided (95% less than 5 micron by cascade impactor) particles over a wide area. At 2200M, 1 March, the weather detachment was advised of this assumption and that the suspected conditions constituted no significant hazard to personnel; however, it was ascertained later that this priority message did not get off the Command Ship until 0500M, 2 March. In addition, NYKOPO KWAJALEIN Flight Able was scheduled for 2 March. The message on this flight also did not get off the Command Ship until early the following morning. KWAJALEIN Flight Able pattern covers all Marshall Islands north of KWAJALEIN and up to TAONGI as a northernmost turning point. Aerial readings taken on the flight at low level are extrapolated to the ground. Flight Able was later directed to make an in-flight report upon reaching TAONGI.

In the meantime, the TG 7.4 commander of the weather island detachment received at 2330M, 1 March, an information copy of the RONGERIK 2100M dispatch to CJTF SEVEN. Not being able to clarify the RONGERIK statement of "100 plus" he decided to send a radsafe monitor to KWAJALEIN to board the regular weather island service flight scheduled to depart KWAJALEIN for RONGERIK at 0830M, 2 March.

About 2000M the task force commander was briefed on the overall situation as was known at this time. This included the results of some initial damage and radsafe survey information taken about noon by helicopter, reports from the sampling aircraft (F-84, B-36 Featherweights and B-36 control), the first twelve hour cloud tracking mission (Wilson 2) and the first few reports on the H/12 to H/24 hour cloud tracker (Wilson 3). The task force commander was advised that fairly heavy contamination had been encountered by Wilson 2 in the sector portion of his flight and that one P2V aircraft had been contaminated in about the same region. The task force commander was advised that the readings taken at ten thousand feet by the cloud trackers were thought to be on the order of magnitude of those encountered by the task force ships. Since the only significant contamination was found in regions which confirmed the forecast cloud trajectories, the requirement for H plus 24 through H plus 48 hour tracking coverage was cancelled at 1930M, 1 March.

Wilson 3 had been advised to expect contamination about half way through the sector portion of his flight. This prediction proved reasonably accurate; intensities were in the 100-500 mr/hr range. Wilson 3, upon completion of his search, proceeded on through the vectored portion of the flight without further contact with radiation. It appeared that all contamination was east of the Wilson 3 sector; however, as later events indicated, Wilson 3 was obviously north of the major fall-out area. An attempt had been made at about 1030M, 1 March to shift the Wilson 3 sector to limiting bearings of 80° to 120° to put the search area deeper into the Marshall Island region. This action was taken on the basis of the RONGERIK dispatch mentioned above. Due to communications delays again, Wilson 3 did not receive the change until after completion of his previously designated search sector.

As a result of the report from RONGERIK, the advisory to CINCPACFLT at 2200M, B Day included revised forecast 72-hour trajectories for ten, twenty and fifty thousand feet and mention of minor fall-out at RONGERIK plus minor fall-out at RONGELAP and other northern Marshall Islands. The fall-out was attributed to an H plus 12 hour change in the forecast air particle trajectory for the twenty thousand foot level. This trajectory, formerly moving toward the ENE, was reforecast to move in a circular clockwise path through south to west. The CINCPACFLT advisory included no health hazard problem for surface and air routes, but that fall-out on Bikini Atoll, as well as damage to structures, would delay re-entry several days. Further, the advisory stated that NYKOPO Flight Able was scheduled for 2 March and that it was not anticipated further action would be necessary.

During the trip back to ENIWETOK on the night of B Day, the fleet encountered a wide area of finely divided (apparently less than 5 micron) particles which caused top-side intensities as high as 350 mr/hr. Appropriate measurures were instituted by the Navy Task Group Commander to the effect that all personnel not essential to open deck duties would remain indoors. Ships' weather doors were closed and the washdown systems operated intermittently. All personnel were debarked at ENIWETOK by about 1000M, 2 March.

The TG 7.4 radsafe monitor order to RONGERIK via KWAJALEIN, arrived over RONGERIK at about 0945M, 2 March. A pass was made over the length of the island where readings from 4 AN/PDR T1B instruments were 200 mr/hr at 500 feet and 350 mr/hr at 250 feet. The latter reading and a request for additional aircraft was relayed back to TG 7.4 via KWAJALEIN. The relay resulted in considerable delay and misunderstandings due to garbles. Upon landing at RONGERIK at 1130M, the monitor advised the detachment to evacuate. The following additional radsafe readings were taken:

a. Inside a building where the men spent most of their time: 600 mr/hr. (Reading was low because the building had been washed down early in the morning.)

b. Outside the above building, waist height: 1800 mr/hr to 2400 mr/hr.

c. Surface of a bed in a living tent: 1200 mr/hr.

Eight men were loaded on the aircraft and evacuated to KWAJALEIN arriving at about 1400M, 2 March. Due to non-availability of additional amphibious airlift, the remaining 20 personnel were picked up on a return trip, and discharged at KWAJALEIN shortly after 1900M, 2 March. All personnel were decontaminated by the TG 7.3 search squadron stationed on KWAJALEIN.

At approximately 1200M, 2 March, Radsafe of the task force was advised of the TG 7.4 monitors intentions to evacuate RONGERIK. In the absence of intensity readings it was mutually agreed not to authorize evacuation and to request radiation intensity readings. This resulted in the puzzling information of "3.2 r/hr at one inch" and the more useful reading of 340 mr/hr at 250 feet. It was mutually agreed (by the TG 7.4 and Task Force Radsafe Officers) that an evacuation was necessary and verbal authority was given to do so. The negative answer to the first request to evacuate

RONGERIK was based on the fact that no intensity readings were available other than the "100 plus" of the previous day, and on the fact that the weather station's off-scale reading had been compared generally with the readings in the task force fleet closer to GZ and with the readings made by the cloud trackers.

No radiation instruments in the roentgen range had been included in the TG 7.4 weather detachment supplies, although such instruments had been recommended by the Task Force Radsafe. A recommendation to supply RONGERIK with film badges was accepted and carried out. The radiac instrument shortcoming arose indirectly from a request that the weather detachments operate and report radiation intensities for the Health and Safety Laboratory, New York Operations Office, AEC (HASL NYKOPO). HASL NYKOPO instruments supplied to all weather island detachments were essentially sealed against moisture in any form. Since no previous test experience indicated high fall-out intensities at islands at similar distances, and since to equip with other types of instruments would have entailed problems in humid storage and maintenance of electronic equipment under conditions of weekly emergency-type re-supply, the decision had been made not to include additional instruments for the weather stations. (It is also noted that the three Army personnel of Project 6.6 placed under the weather detachment, had also been directed by Program 6 personnel to include an AN/PDR T1B in their equipment. No such instruments were included.)

In the decision to authorize the RONGERIK evacuation, consideration was given to the fact that only U.S. troops were being removed whereas native populated atolls were also undoubtedly contaminated to the same or higher degree. The informal decision to remove only RONGERIK personnel was made on the basis of urgency and incontrovertible necessity and because it was the only atoll on which there was positive evidence of the exact ground contamination. It was decided that the inference of similar contamination on other atolls in the vicinity should be considered by the Task Force Commander. Accordingly, the Task Force Radsafe Officer, in conference with the Task Force and Task Group Commanders, and the Scientific Director, presented the fall-out situation as it was known at that time (approximately 1330M, 2 March). The twenty thousand foot forecast trajectory (modified post-shot) was believed to be the primary factor in the movement of contamination south of the predicted fall-out area. It was assumed that a considerable number of adjacent populated atolls in a general "horse-shoe" shape were affected. The commanders were advised that the NYKOPO Flight ABLE had been requested the previous night and that this flight had been instructed to make an in-flight report upon reaching TAONGI

Before the conference was over, an in-flight report from Flight ABLE indicated 1350 mr/hr at 1340M, 2 March on the ground at Rongelap Island, 400 mr/hr at 1328M at AILINGINAE and 1.0 mr/hr at 1300M for WOTHO. The decision was reached at the conference that an evacuation of RONGELAP was necessary and that others likely to be involved, would be determined on the basis of readings from the remaining portion of the Flight ABLE pattern

Accordingly, it was decided to start a destroyer on the way to RONGELAP immediately and to set up an SA-16 amphibian with monitors to check the surface conditions at RONGELAP before dark. The destroyer was directed to be off RONGELAP ready to start evacuation at dawn the following day. A Trust Territory representative with interpreter was requested to move by PBM from KWAJALEIN to arrive at RONGELAP at the same time. The SA-16 was set up, two responsible monitors were especially briefed to make readings at waist height, use several meters of the same type for comparison and to use different types for cross-check. An average reading of 1.4 r/hr at approximately 1700M made in the living area of RONGELAP Island by these monitors was used in the decision the same night to order the destroyer to commence evacuation operations at dawn. Evacuation operations began about 0730M, 3 March and were completed by 1030M, the same date. It developed that all of the natives away from the living area had returned home in order to discuss the unusual phenomena of the visible light and audible shock. This factor simplified the evacuation operation by concentrating all natives on the home island of RONGELAP. Interrogation of natives disclosed that all were present except 17 who were fishing at AILINGINAE. Following the RONGELAP operation, the destroyer proceeded to AILINGINAE, removed the remaining 17 and proceeded to KWAJALEIN. A total of 17 males, 20 females, 15 boys and 14 girls were removed by destroyer and disembarked at KWAJALEIN. 16 old and sick were moved at about 0930M by PBM to KWAJALEIN. Decontamination of all natives was accomplished during the trip to KWAJALEIN.

The full report from Flight Able received approximately 1900M, 2 March indicated UTIRIK ground contamination at 240 mr/hr at 1651M, 2 March and 76 mr/hr at about 1716M, 2 March at AILUK, the nearest populated island to the south. BIKAR, the nearest island to the north was determined to be unpopulated and contaminated to about 600 mr/hr at about 1628M, 2 March. TAONGI, the next nearest island to north at 1525M was 1.4 mr/hr and unpopulated. Based on these facts a decision was made to start another destroyer to UTIRIK to anticipate an order to start evacuation at dawn on 4 March. In the meantime a PBM was set up to ground survey UTIRIK on 3 March while the destroyer was on the way. This ground survey, conducted in the same manner as that for RONGELAP, indicated 160 mr/hr at 1830M, 3 March. The infinity dose of the UTIRIK natives was computed at 58r. The decision to evacuate was made and the destroyer ordered to start evacuation the following morning, 4 March. The evacuation commenced at 1100M and was completed by 1300M. A total of 47 males, 55 females, 26 boys and 26 girls were removed, decontaminated on the destroyer enroute to KWAJALEIN and disembarked on 5 March. Questioning of natives disclosed that all had been removed. The destroyers which evacuated RONGELAP and UTIRIK were directed to obtain drinking water samples from these atolls. A check of the water samples indicated from 2 to 28 times the task force standard for full time usage.

With the decision to evacuate UTIRIK made and the machinery set in motion to accomplish this operation, the status of AILUK was put up for consideration approximately 2000M, 2 March. This atoll has a reported population of 401. The infinity dose was determined at less than 20r, i.e., less than the standard used by the task force for its sampling aircraft crews. This was the major factor in the decision not to evacuate AILUK. All other populated atolls on the Flight Able pattern received less contamination than AILUK.

During the afternoon of 2 March a directive was issued to execute KWAJALEIN NYKOPO Flights BAKER and CHARLIE on 3 March. These flights cover all Marshall Islands south of KWAJALEIN. The flights were set up on the assumption that the twenty thousand foot trajectory could have brought contamination arount to the south and west and contaminated some of the southern Marshalls. (The flights were executed on 3 March. No significant ground contamination was found. An additional NYKOPO type flight (designated KING) was performed over the Gilbert Islands on 6 March for the same reasons. At the request of the Task Force, CINCPACFLT obtained advance clearance from the British for the Gilberts flight. The maximum of 0.08 mr/hr on 6 March was reported through CINCPACFLT to the U.S. Naval Attache in London.) Several special reports on activities through 2100M, 2 March were dispatched to the AEC, Army and CINCPACFLT.

Throughout the actions involving evacuation of natives, the standard reference used to determine whether or not an atoll was populated was OpNav P22-100-M, June 1951, Trust Territory of the Pacific Islands. On the basis of the 17 natives on AILINGINAE (reported to be unpopulated), confirmation was obtained from the Trust Territory representative at KWAJALEIN relative to the status of other atolls involved in significant fall-out. Of particular interest were BIKAR and TAKA for BRAVO fall-out and TAONGI for future shots. These atolls proved to be unpopulated as reported; the natives on AILINGINAE were not permanent residents, having temporarily occupied AILINGINAE for fishing purposes.

The routine daily advisory to CINCPACFLT on the evening of 2 March indicated no change in the forecast 72-hour cloud trajectories and no health hazard problems for surface and air routes or land areas other than those covered in previous special summaries to the AEC, C/S Army and CINCPACFLT, and that all special and routine flights to date confirmed the significant fall-out area. The advisory stated that the highest reading recorded was at RONGELAP Island with 1.5 r/hr at the surface at H plus 36 hours, and that lesser but significant fall-out was suspected at UTIRIK. CINCPACFLT was informed that ground monitoring would be conducted at UTIRIK on 3 March, that appropriate action would be taken, and that NYKOPO Flight BAKER and CHARLIE would be flown on 3 March.

On 3 March a special advisory was dispatched to CINCPACFLT to the effect that NYKOPO Flights BAKER and CHARLIE indicated less than 10 mr/hr at all atolls, that no further health hazard problems were existent or forecast, and that Johnston Island was continuously reporting negative contamination. Nevertheless, it was recommended that all Hawaii NYKOPO flights be made as a precautionary measure. The 2000M, 3 March routine advisory to CINCPACFLT stated that the BRAVO cloud was forecast outside the area of Task Force information and as a consequense, the forecast 72-hour air particle trajectories were terminated. The advisory included the results of the UTIRIK ground survey and the fact that documentary photography, water and soil samples were taken. The advisory included the current status of the RONGELAP and UTIRIK evacuation and details of a conference between CJTF SEVEN and COMNAVSTAKWAJ reference care of natives. In particular, the advisory mentioned that task force funds had been authorized to cover extra expenses incurred by the Trust Territory in caring for the natives and suggested that the CINCPACFLT Surgeon assume medical responsibility for evacuated natives at KWAJALEIN and other sites as required.

During this period of time, a special effort was organized to care for the natives and study the effects of the radiation on them. This effort became known as Project 4.1 in the military effects program. A complete coverage of this aspect of the evacuation is contained in the final report of Project 4.1.

At 2000M, 4 March, the final routine advisory was dispatched to CINCPACFLT with a statement that further advisories would be contingent upon the circumstances. This dispatch included a statement that the evacuation of UTIRIK was completed by H plus 78 hours with 17r as the best estimate of dose received by the natives. Further, the advisory included notification of Flight ABLE scheduled for 5 March.

It should be noted that the pattern of routine advisories set up for CINCPACFLT, the AEC and the C/S, Army were only a part of the total dissemination of information relative to post-BRAVO events. From the beginning, a number of special advisories and information copies of planned Task Force actions were forwarded to these agencies as the facts or plans became firm. In particular, reports on the condition of the natives were maintained until near the end of the operation, and copies of the detailed plans for the several surveys were dispatched to CINCPACFLT and HICOMTERPACIS as appropriate.

On the basis of Flights ABLE, BAKER and CHARLIE, it was determined that no further atolls would need to be evacuated. The effort was therefore concentrated on those populated atolls indicating more than 10 mr/hr at H plus 24 hours and which were not evacuated. For this purpose a special survey was set up under the technical direction of Dr. Thomas N. White, H Division, LASL, assisted by Major Robert Crea, Headquarters, JTF SEVEN, to start from KWAJALEIN on 5 March by PBM. Due to the hazardous conditions for PBM operations at LIKIEP, AILUK, JEMO and MEJIT, these atolls were assigned to a destroyer. The destroyers party was also directed to check PACMICLINE M/V Roque, reported to have arrived at UTIRIK (from KWAJALEIN) at 1000M, 2 March and to have departed UTIRIK for AILUK at 0700, 3 March.

Following the survey under Dr. White and Major Crea, the next effort was directed toward acquiring data on the evacuated atolls in order that the effects of the radiation could be better evaluated. The investigation included ground monitoring and the taking of soil and water samples from living areas. Secondary purposes were efforts to reduce the adverse impact on real and personal property of the hasty departure, to determine radiation data of scientific interest and to evaluate the time of re-occupancy by the former inhabitants. This effort was assigned to a destroyer in order that working parties would have a floating base for operations ashore and decontamination facilities afloat. The technical direction of the effort was placed under the supervision of Dr. Herbert Scoville, Technical Director, Armed Forces Special Weapons Project, assisted by representatives of CASTLE Project 2.5a. The rehabilitation portion of the effort was placed under the supervision of the commanding officer of the destroyer. The party with equipment departed 7 March for KWAJALEIN to join with a Trust Territory representative in a PBM rendezvous with the destroyer at RONGELAP early morning of 8 March.

Arrangements were made to air ship soil and water samples to Health and Safety Laboratory, AEC, New York Operations Office, Attention Mr. Merril Eisenbud. Mr. Eisenbud was requested to provide the task force with decay information and activity per unit area on the soil samples and activity per unit volume on the water samples. He was also requested to make such other analysis as he thought necessary considering the unusual circumstances and interest in BRAVO Event.

Detailed reports by Dr. White, Dr. Scoville and Major Crea have been distributed separately to interested agencies. (See Tab H.) Continuing surveys of the evacuated atolls were made for picking up of animals for medical studies, rehabilitation and for studies of marine life. Reports on these activities were included in the above distribution as they became available. (Tab H.)

On 6 March, CINCPACFLT requested COMNAVMARIANAS to provide information on the PACMICLINE movements within 600 NM of the ENIWETOK-BIKINI Danger Area until May. The request stated that the information was required as a precautionary safeguard during current JTF SEVEN operations. As a consequence, daily reports were received by the Task Force on the movements of these vessels. In no case were PACMICLINE vessels involved in significant fall-out areas.

On 8 April information was received from COMNAVMARIANAS to the effect that COMNAVMARIANAS had been charged with monitoring copra on PACMICLINE vessels at GUAM and requested confirmation and results of reported monitoring by Dr. White at MAJURO of copra loaded on PACMICLINE M/V Roque. COMNAVMARIANAS was informed that the Roque was monitored on arrival at MAJURO, 1630M, 7 March by Dr. White (AEC) with the following results (in mr/hr): 2 to 3 inside main deck structure, 10 on open decks, 5 to 8 in sleeping quarters, 10 to 30 on rope and canvas, no specific readings on copra, but that the entire survey indicated no health hazard.

On 8 March information was passed to CINCPACFLT relative to the PATAPSCO (AOG-1) and the MERAPI (AF-38). These vessels were located as indicated in Inclosure 15. CINCPACFLT was advised that the PATAPSCO should be given a radiation survey over topside on arrival at Pearl if the radiation levels could not be determined enroute. Best estimates indicated that the northern fringe of the cloud could have reached the PATAPSCO by H plus 8 hours with the ship moving away from the general main cloud path. TG 7.3 was requested to give the MERAPI a radsafe survey upon arrival at BIKINI as a precautionary measure. (Subsequent monitoring of the MERAPI on 9 March disclosed negative contamination.) Relative to the PATAPSCO, information from CINCPACFLT on 20 March indicated the following: an accurate estimate of the actual accumulated exposure of the 103 personnel on the PATAPSCO (AOG-1) was not possible; film badges or phosphor glass was not utilized as the ship had no knowledge of fall-out. Heavy seas the entire voyage probably reduced topside levels. The 9 March blood count was given as follows: mean WBC 8180, platelets 261,000, segs 51, lymphs 37.9, hematocrit 47.7, no significant individual variations. The 18 March blood count was given as follows: mean WBC 8363, platelets 240,488, segs 59, lymphs 36, hemetocrit 46.5, no significant individual variations. Lowest WBC 5300, no symptoms. Overall evaluation — not significant. Urine samples being forwarded BuMed for FP studies.

Throughout March and part of April several reports were received which indicated Japanese fishing vessels arriving in port with contaminated tuna, some of which was destroyed. No illness was reported on crews other than that of the Fukuryu Maru. Based on the reports, it appeared that contamination of the tuna was not significant.

On 8 May a Japanese survey party started from Tokyo to conduct a Biological, Oceanographical and Meteorological research on the effects the fisheries of Japan received from the thermonuclear blast experiments. The survey made studies at points 500, 700 and 900 NM from BIKINI. In July, the results of this survey indicated contamination existed in the waters at considerable distance from BIKINI, but that the levels were too low to be considered of any significance.

13 Inclsr

1. Memo for Record, Subject: "BRAVO Shot, Operation CASTLE", dated 12 Apr 54
2. An Evaluation of Weather Forecasts for BRAVO
3. Tabulation of BRAVO Pre-shot and Post-shot Winds from Task Force Stations
4. Forecast and Computed BRAVO Air Particle Trajectories
5. BRAVO Ground Zero Hodographs
6. Air Radsafe Operations for BRAVO
7. BRAVO Shot Day Ground Radiation Intensities On-site (A and B)
8. SRD-229-54E - Radioactive Contamination of Ships and Radiological Contamination of Personnel of Task Group 7.3 due to BRAVO, the First Nuclear Explosion of CASTLE
9. Preliminary Results NYKOPO Air borned Monitoring Flights o/a 1 Mar 54
10. Discussion of Off-site Fall-out, BRAVO
11. Pattern of Fall-out Following BRAVO Event (2 Appendices)
12. Medical Aspects of Fall-out from BRAVO
13. Memo for Record, Subject: "Protection of Transient Shipping during Operation CASTLE

12 April 1954

MEMORANDUM FOR RECORD

SUBJECT: BRAVO Shot, Operation CASTLE

1. PURPOSE: To make a matter of record operational aspects that were considered prior to BRAVO event of Operation CASTLE and to analyse the resultant situation in the light of available pre-shot and post-shot information.

2. GENERAL INFORMATION: Operation CASTLE is planned to consist of a series of seven detonations at the Pacific Proving Grounds, which encompasses ENIWETOK and BIKINI Atolls. BRAVO is the code name that was given the firing of the first device, at 0645M on 1 March 1954, off NAMU Island, BIKINI Atoll.

Subsequent to BRAVO detonation radioactive debris fell on certain inhabited atolls of the northern Marshall Islands. Radiation intensities rose to levels sufficient to warrant evacuation of four atolls and all personnel were removed from these atolls to KWAJALEIN in accordance with the operational emergency plan of JTF SEVEN. Areas evacuated and gamma dosages received are indicated below:

ATOLL	POPULATION	DISTANCE FROM GROUND ZERO	DOSES RECEIVED
Ailinginae	17	79 NM	80 R (computed)
Rongelap	65	100 NM	100-130 R (computed)
Rongerik	28 #	133 NM	40 -98 R (film badge)
Utirik	154	270 NM	17 R (computed)

28 American Service personnel; 25 USAF Weather Detachment plus 3 USA Signal Corps personnel.

All evacuees are under competent medical care.

3. PREVIOUS EXPERIENCE AND CHARACTERISTICS OF NUCLEAR DETONATIONS: Radioactive debris is an inherent characteristic of all nuclear detonations. It originates from fission fragments which are the residue of bomb elements and surface materials, soil and water, made radioactive by accompanying radiation fields. Debris is sucked high into the atmosphere by after-winds of the explosion. Where this radioactive debris will fall is a major pre-shot consideration and primarily influences the decision to detonate a nuclear explosion at a certain time.

INCLOSURE #1

The area over which radioactive debris is spread and the intensity of fall-out on the ground are determined by the yield of the explosion as well as by wind pattern since the larger the yield, the more surface materials are sucked up into the cloud and the more fission fragments are available. The relationship between yield and fall-out is known only qualitatively.

4. PRE-SHOT INFORMATION: The operational aspects of the BRAVO experience were planned and conceived in the light of experience gained from previous operations. These factors were considered:

a. The basis for forecasting where fall-out will go is experience gained from overseas test operations CROSSROADS, SANDSTONE, GREENHOUSE and IVY and to a certain extent from tests at the Nevada Proving Ground. Prior to the firing of BRAVO, only one megaton yield device (IVY-MIKE) had been detonated. Although conscientious efforts were made to document the fall-out from MIKE, only about 5% of the total debris could ever be accounted for.

The technique used for forecasting fall-out patterns is to consider the cloud as a small area source (about a 15 mile radius); then add vectorially forecast winds from the surface to approximately 100,000 feet. The next step is to outline an area on the ground where fall-out is expected. This area is computed by taking into consideration particle size, diffusion into the atmosphere, wind pattern, yield and source radius. Such patterns have been largely confirmed by experience in Nevada as well as by the meager data available here.

b. The most probable value of the yield from BRAVO was predicted to be three to five megatons or one half the value of the IVY-MIKE yield. The upper limit of yield was considered to be of the order of eight megatons.

c. The surface radex was plotted, with an insurance factor added, i.e., smaller particles than previous experience indicated necessary were considered. This doubled distances from ground zero where fall-out was predicted to occur.

d. The upwind intensity of radiation levels at various distances was considered to be the same order of magnitude as for IVY-MIKE. Radiation versus distance lines were transposed to BIKINI Atoll.

e. A critical problem in predicting fall-out involves forecasting the stability or lack of stability of the wind pattern after shot time. Since radioactive particle travel is determined primarily by the winds at each level, it is required that winds must be from favorable directions or varying within the outer limits on favorable directions during the time of fall-out. The critical fall-out period was considered to be on the order of twelve to eighteen hours for significant fall-out to occur. The variation in time arises from considerations of wind shear, with more diffuse and less significant intensities at a given time associated with large angular and speed shear. For this reason, it was required that actual wind observations and forecasts immediately before shot time and throughout shot day be continuously considered in their relation with the forecast conditions for the first twenty-four hours after the shot.

5. PRE-SHOT BRIEFINGS: The following were presented at the pre-shot command briefings:

a. Weather

Weather conditions during the five days prior to BRAVO indicated a favorable trend for BRAVO day with easterly winds below 15,000 feet and winds of a southerly component above. The situation presented at H-6 hours for the subsequent 24 hour period (18 hours after shot time) was satisfactory. The 24 hour period to begin 18 hours after shot time was predicted to give an unfavorable trend as northwest winds were forecast for the 10,000 to 20,000 foot levels.

b. RedSafe

(1) Resultant wind diagrams including latest observed winds and forecast winds for H Hour and the 72 hour cloud trajectories, which gave a fall-out pattern in a narrow sector to the east northeast and a wide (140°) sector to the south with very slow resultant winds.

(2) Surface radex, H to H plus 6 hours.

(3) Outlooks for:

(a) BIKINI: Unfavorable; ENIWETOK: Favorable; UJELANG: Favorable, and the native populated atolls in southeast quadrant from ground zero favorable, since resultant winds in the direction of these areas were considered too slow to move significant fall-out to the atolls involved.

(b) Task Force Fleet: Favorable, provided ships moved out at least 50 miles.

(c) Air routes through WAKE and KWAJALEIN: favorable.

(d) Surface routing inside 500 miles considered in its relation to all known transient shipping: favorable.

c. Scientific

(1) High altitude sampling operations - favorable.

(2) Light transmission for scientific experiments - favorable.

6. CONCLUSIONS:

a. Lack of fall-out information from previous shots of comparable yield was a serious handicap.

b. The yield of BRAVO was three times the most probable value and twice the probable upper limit with the result that more debris was carried up and diffused over a much larger area than was thought possible.

c. The original source cannot be considered as a point or a relatively small area but must be considered to be an area of about fifty miles in diameter. This diameter also depends on yield.

d. The radioactivity of the debris can be considered proportional to yield. Radioactive material in the BRAVO cloud was thus two to three times than was expected.

e. An appreciable fraction of the observed fall-out can only be accounted for by assuming that it originated in the stratosphere. For such particles to reach the ground at observed times, their diameter must have been in excess of 100 microns.

f. Forecast for shot time winds at shot time was essentially correct. Variation from forecast trajectories was approximately 10 degrees in significant upper levels; unfortunately, the variation was in the wrong direction (See Incl 4). The small variations observed at lower levels were also in an unfavorable direction. Nevertheless, the accuracy of the winds aloft forecast approached the limits of accuracy of the wind observations themselves and were well within the normal forecast error.

g. The fallout pattern extended from the BIKINI Atoll to the east northeast. Considerable widening of the pattern took place due to diffusion. The intensity of the pattern on the ground was due primarily to superposition of mushroom cloud fall-out on the stem cloud pattern; and the superposition can be attributed to the narrow cone within which the winds were acting. The theory that a significant fall-out does not come from the stratosphere is not substantiated by the facts of BRAVO.

h. For future high yield shots, the forecast and observed winds for the first twenty-four hour post-shot period should receive as much emphasis as analyses made for shot time.

7. EVACUATION: Evacuation took place in accordance with the operational emergency plan and without incident. Evacuation was not effected prior to detonation because no significant fall-out was expected on inhabited areas.

(NOTE: Pertinent inclosures attached in support of this memorandum have been included elsewhere in this report. The inclosures covered forecast air and surface RADEXES, forecast and observed shot time winds, a discussion of pre-shot and post-shot weather, a chronology of Radsafe actions, a description of the off-site fall-out, post shot analysis of the fall-out pattern and the medical aspects of the evacuees involved.)

AN EVALUATION OF WEATHER FORECASTS FOR BRAVO

1. Summary of weather immediately prior to B-Day: The evening before B-Day there had been scattered cumulus and broken cirrus. This cirrus had been occasionally overcast with bases from 35,000 to 38,000 feet. The same general sky condition had been prevalent throughout the area during the ten day period prior to B-Day. Easterly winds had prevailed from the surface to 8000 feet. Only one rain shower had been reported the evening before the shot.

2. The Weather Forecast: 2/8 cumulus, bases 2000 feet; 2/8 stratocumulus, bases 6000 feet; 4/8 thin cirrus, base near 38,000 feet; widely scattered light showers.

a. Observed weather: 4/8 cumulus, base 2000 feet; 1/8 altostratus (barely discernible); 5/8 to 6/8 thin cirrus, base 38,000 feet; no showers at shot site.

b. Comments on weather: Wilson 1 (reconnaissance aircraft near shot site) reported 2/8 to 4/8 cumulus prior to shot time. Immediately before the device was detonated 1/8 altostratus was reported which increased to become 5/8 altostratus at 25,000 feet by 1138M. At 0822M Wilson 2 reported 6/8 cirrostratus layer at 40,000 feet. The summation of the altostratus and cirrostratus layers formed a broken to overcast condition during the rest of the day. No rain showers were reported.

3. The Wind Forecast:

HEIGHT (Thsd Ft)	H-48	H-38	H-24	H-14	H-8	H-4	OBSERVED BIKINI (H HOUR)
90			100/18	100/18	070/30	070/20	
80			090/12	090/12	080/25	080/25	
70			070/14	070/14	080/09	080/09	
60	SE/5-15	360/10-15	050/10	050/10	Lt&Var	Lt&Var	340/27
55			Lt&Var	Lt&Var	050/10	050/10	200/16
50	SW/10-20	220-250/20	230/14	230/14	260/38	260/38	250/31
45			240/20	240/20	240/40	240/40	250/45
40	S/15-25	220-250/20	250/24	250/24	230/38	230/38	250/44
35			260/22	260/22	240/28	240/28	230/35
30	SE/15-25	180/5-10	250/14	250/14	230/26	230/26	240/35
25					230/20	230/20	250/26
20	E/15-20	090/10-15	230/16	230/16	270/12	270/12	280/23
15					250/18	250/18	240/14
10	E/10-15	080-090/15-20	090/14	S/10	Lt&Var	Lt&Var	310/10
05					070/16	070/16	100/09
SFC	E/15-20	080-090/15-20	070/20	070/20	070/20	070/20	060/12

INCLOSURE #2

a. Comments on winds:

(1) 58% of the forecast wind directions were within 10 degrees of the observed; 75% were within 20 degrees. Of those that deviated by more than 20 degrees, one had a speed of 9 knots, and one (10,000 ft.) forecasted as light and variable was observed as 310 degrees at 10 knots. The greatest deviation from the forecast winds was at 55,000 feet immediately below the tropopause. The flow pattern at 10,000 feet had been ill defined. A weak outdraft formed to the north of BIKINI about 36 hours before the shot. Then 15 hours before the shot, a weak indraft appeared 200 miles north of BIKINI, and the outdraft was forced south. The perturbations had no apparent connection with the circulation above and below 10,000 feet; therefore a forecast for light variable winds at 10,000 feet was issued. When a more definite forecast was desired, a statement was issued to the effect that a trend toward westerly winds at 10,000 feet was expected.

(2) 42% of the forecast wind speeds deviated 6 knots or less from the observed, and 88% deviated 10 knots or less. The maximum error was 11 knots at 20,000 feet.

BRAVO

Date 1 MAR 1954 Time 0600 L Clouds lower 4/8 CU Base 2,000

Tops 4000 Middle 1/8 AS Base 17,000 Upper 6/8CS 40,000

Visibility 15 Miles Sea Level Pressure 1006.1 Mb Wind direction 070 degrees Velocity 15 Kts

Surface temp 80 °F Dew Point 72 °F Humidity 77 % Vapor pressure .783

Local weather PARTLY CLOUDY

Remarks NO INDUCED SHOWERS

Latest winds aloft taken on CURTISS Position BIKINI Time 0600M

ALTITUDE	DEGREES	KNOTS	PRESSURE	TEMP	DEW POINT	HUMIDITY
Surface	060	12	1006.1MB	26.7°C	22.2°C	77%
1,000 Ft	070	17				
2,000	080	18	942	21.0	19.9	90
3,000	090	17				
4,000	090	14	876	16.4	15.7	90
5,000	100	9				
6,000	120	4	815	13.8	9.7	74
7,000	310	4				
8,000	310	5	759	13.7	-5.7	25
9,000	320	7				
10,000	310	10	705	9.1	-3.2	41
12,000	300	7	653	5.1	-8.6	36
14,000	290	14	606	2.7	-15.6	25
16,000	290	13	561	-1.9	-14.3	38
18,000	280	13	522	-4.6	-20.0	29
20,000	280	23	485	-8.7	-19.9	40
25,000	250	26	396	-18.8	-30.2	35
30,000	240	35	323	-31.8		
35,000	230	35	260	-44.2		
40,000	250	44	208	-56.7		
45,000	250	45	166	-67.8		
50,000	250	31	132	-76.7		
55,000	200	16	104	-80.4		
57,000	340	27				

K-22

BIKINI-BRAVO SHOT, 0645M, 1 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+6 hours
Surface	0518	0921	0612	0715	No Run Made
2000	0820	0719	0818	0720	
4000	0815	0815	0914	0910	
6000	0905	0707	1204	0811	
8000	3311	0205	3105	3006	
10000	3215	3312	3110	1511	
12000	2217	2514	3007	3218	
14000	2809	2715	2914	3310	
16000	2915	2615	2913	3515	
18000	2916	2917	2813	3023	
20000	2822	2728	2823	2923	
25000	2121	2224	2526	2122	
30000	2324	2231	2435	2331	
35000	2343	2238	2335		
40000	2444	2238	2544		
45000	2437	2538	2545		
50000	2706	2631	2531		
55000		3211	2016		
60000		0221	3427		

ENIWETOK-BRAVO SHOT, 0645M, 1 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0618	0717	0717	0717	0715
2000	0817	0821	0820	0820	0914
4000	0915	0816	0817	0815	0912
6000	3004	Calm	Calm	0603	2803
8000	2705	2908	3111	2910	2808
10000	2506	2809	2911	3010	2810
12000	2008	2408	2610	2508	2809
14000	2407	2406	2407	2507	2810
16000	2908	2812	2613	2712	3211
18000	2515	2615	2817	2817	2817
20000	2610	2617	2817	2917	2822
25000	2525	2325	2425	2625	2729
30000	2429	2329	2528	2633	2732
35000	2337	2335	2437	2339	2629
40000	2442	2530	2442	2531	2639
45000	2445	2430	2623	2532	2633
50000	2446	2523	2719	2626	2816
55000	2439	0209	3011	3207	2705
60000	2615	0904	3304	Calm	
65000	0616	1003	3206	Calm	
70000	0610	0712	0827	0813	
75000	2507	0821	0813	0818	
80000	0603	0729	0830	0836	
85000	0617	0932	0747	0813	
90000	0631	0834			

K-24

KUSAIE-BRAVO SHOT, 0645M, 1 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H/5 hours	H/9 hours
Surface	Calm	2405	Calm	0607	1211
2000	1107	Missing	1007	0724	0923
4000	1113	1112	0906	0722	0825
6000	1010	1006	0904	0707	0728
8000	0908	0802	0904	1602	3102
10000	1111	0809	1104	2110	3003
12000	1110	0711	0403	1407	2708
14000	1110	1008	0907	1319	2612
16000	0910	0910	1210	1418	2409
18000	0810		1317	1520	2205
20000	1216		1316	1721	2706
25000	1220		1108	2015	1909
30000	1819		1004	1615	1609
35000	2114		1208	1516	1816
40000	2020		1215	1416	1424
45000	1827		1322	1313	1428
50000	1719		1611	0106	3605
55000	1007		1409	0503	0210
60000			3512		2521
65000			2915		2824
70000					1324
75000					0934
80000					1242
85000					1157

K-25

KWAJALEIN-BRAVO SHOT, 0645M, 1 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0512	0610	0710	0510	0510
2000	0715	0824	0820	0819	0715
4000	0912	0918	0917	1016	0810
6000	0916	1017	0817	1109	1506
8000	1006	0714	0613	0507	1305
10000	3206	3208	3203	0104	2033
12000	3106	3108	3211	3109	2907
14000	2906	3006	3113	3210	3210
16000	2606	1705	3006	3309	3314
18000	3312	3511	0108	3311	3309
20000	2916	3424	3007	3011	3314
25000	1922	1121	2026	1819	2215
30000	2322	2422	2421	2325	2226
35000	2234	2235	2322	2432	2430
40000	2530	2539	2435	2535	2340
45000	2525	2534	2431	2433	2422
50000	22__	2331	2323	2519	0408
55000	3407	3310	3613	0117	0605
60000	2512	3205	2614	3008	2512
65000	0206	3008	2407	2706	3103
70000	Missing	3110	0611	0817	0909
75000	0721			0825	0829
80000	0944			1044	0833
85000	0946			0845	

MAJURO-BRAVO SHOT, 0645M, 1 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+11 hours
Surface	0709	0512	0414	0509	0312
2000	0624	0620	0621	0619	0517
4000	0414	0716	0816	0818	0915
6000	1119	1215	1217	1112	1312
8000	1114	1212	1112	2004	1205
10000	0306	0107	0308	3609	0203
12000	1709	3408	3407	Missing	3111
14000	1804	3204	3003	Missing	3108
16000	1803	3205	3411	Missing	3403
18000	1610	3407	3509	Missing	0103
20000	1810	3410	3407	1405	0109
25000	1320	1716	1509	1908	1709
30000	2124	2121	2223	0757	2022
35000	2034	2231	2332	0954	2233
40000	2145	2337	2244	2340	2331
45000	2234	2614	2337	2343	2438
50000	2433		2528	2445	2628
55000			2317	3114	3220
60000			2609	3219	2324
65000			2706	3118	3411
70000			0825	0916	1210
75000			0937	0736	0725
80000			0847	0757	0844
85000			0849	0954	0950
90000				0860	1144

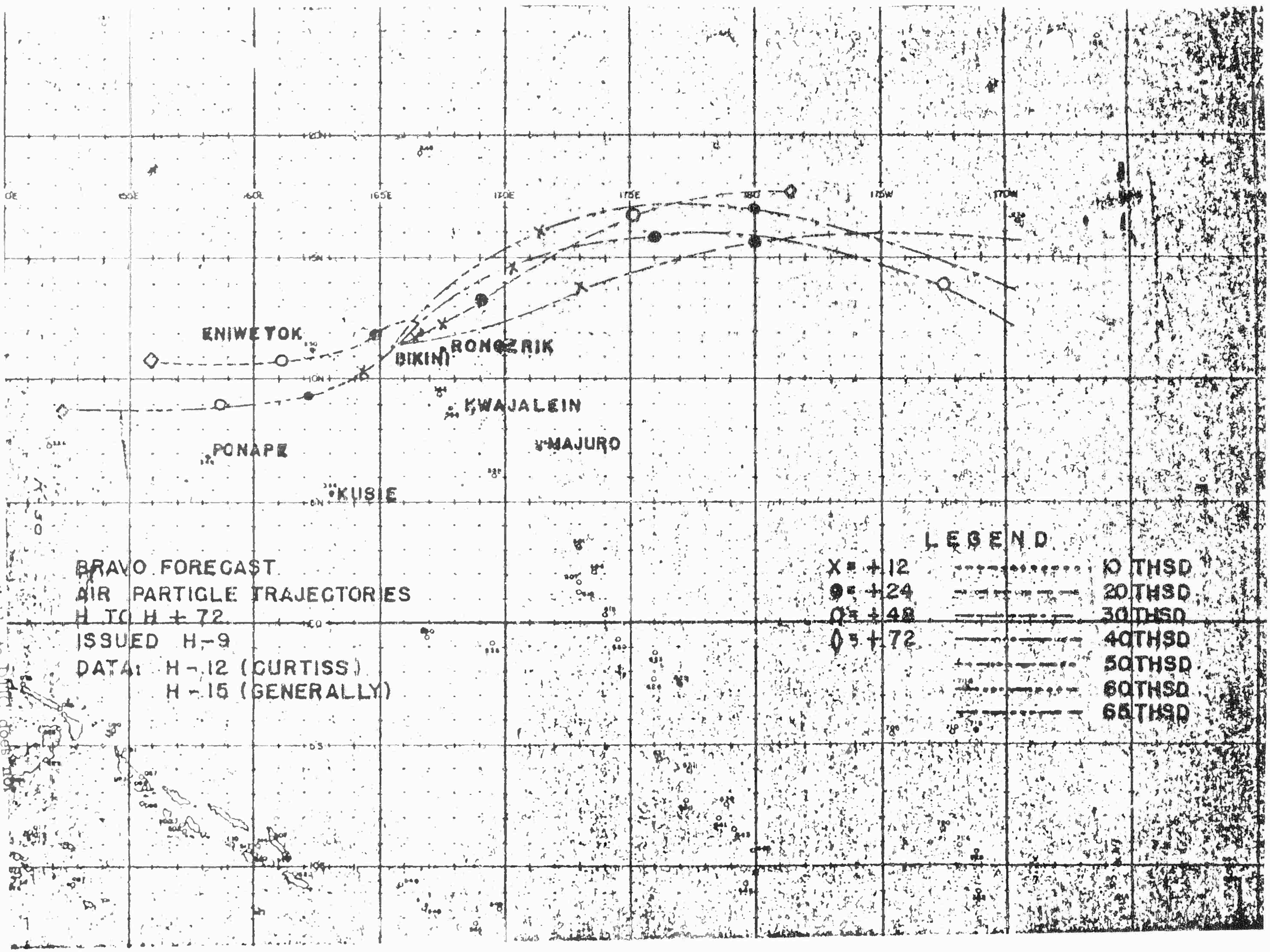
PONAPE-BRAVO SHOT, 0645M, 1 MARCH 1954

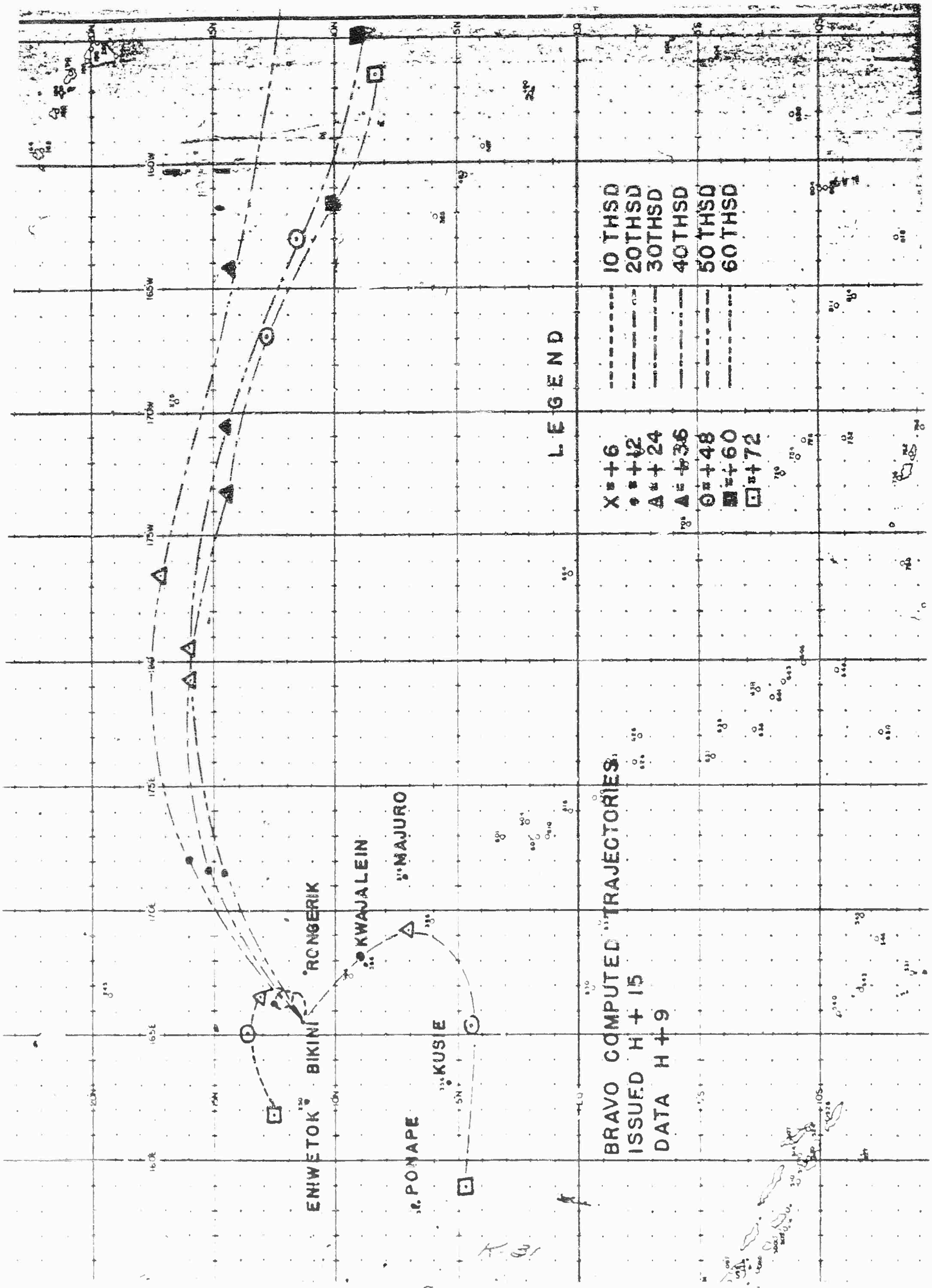
LEVEL	H-9 hours	H-2 hours	SHOT	H+4 hours	H+9 hours
Surface	0907	Calm	0904	Calm	Calm
2000	0722	0818	0618	0818	0715
4000	0821	0822	0915	0919	0818
6000	1015	0914	1109	0919	0912
8000	1414	1411	1508	1109	1503
10000	1210	1512	1408	1310	1602
12000	0709	1808	1605	1508	0303
14000	0413	2803	3202	1044	3002
16000	0310	Calm	1702	1003	3003
18000	0702	Calm	1504	0704	2202
20000	1705	Calm	2003	2504	2505
25000	1716	2611	2312	1405	1809
30000	1823	1620	1612	1710	1716
35000	2018	1517	1521	1526	1618
40000	1817	1621	1522	1615	1918
45000	1622	1815	1612	1511	1719
50000	0920	0508	3414	3310	2204
55000	0705	0517	3412	0502	1002
60000		1704		1904	0202
65000		2915		3107	0513
70000		0720		1111	0802
75000		1032		1124	1208
80000		0941		0945	1109
85000		0949		0953	0935
90000		0944		0956	0964
95000		0951		0964	0977
100000				0964	0895

K-28

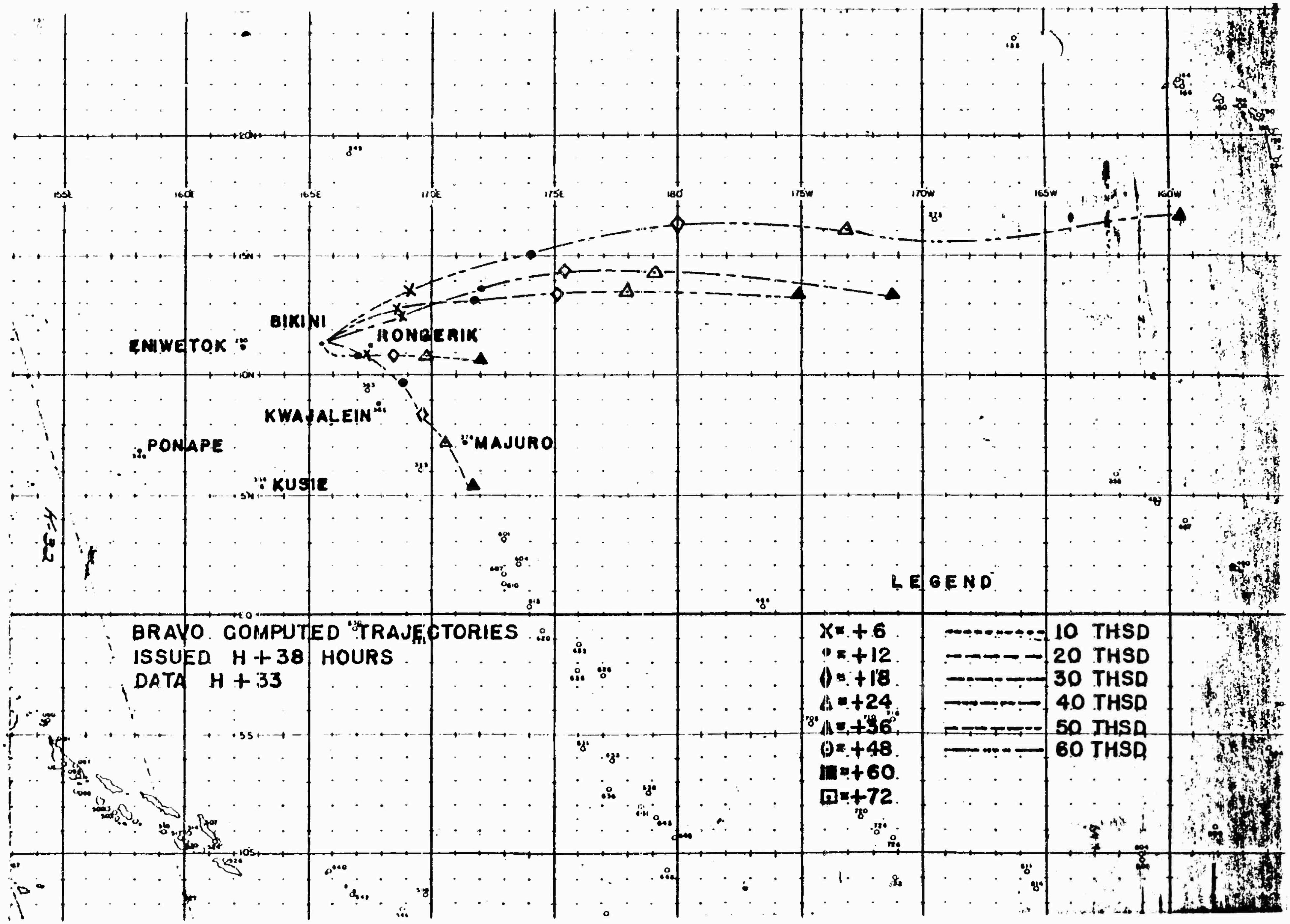
RONGERIK-BRAVO SHOT, 0645M, 1 MARCH 1954

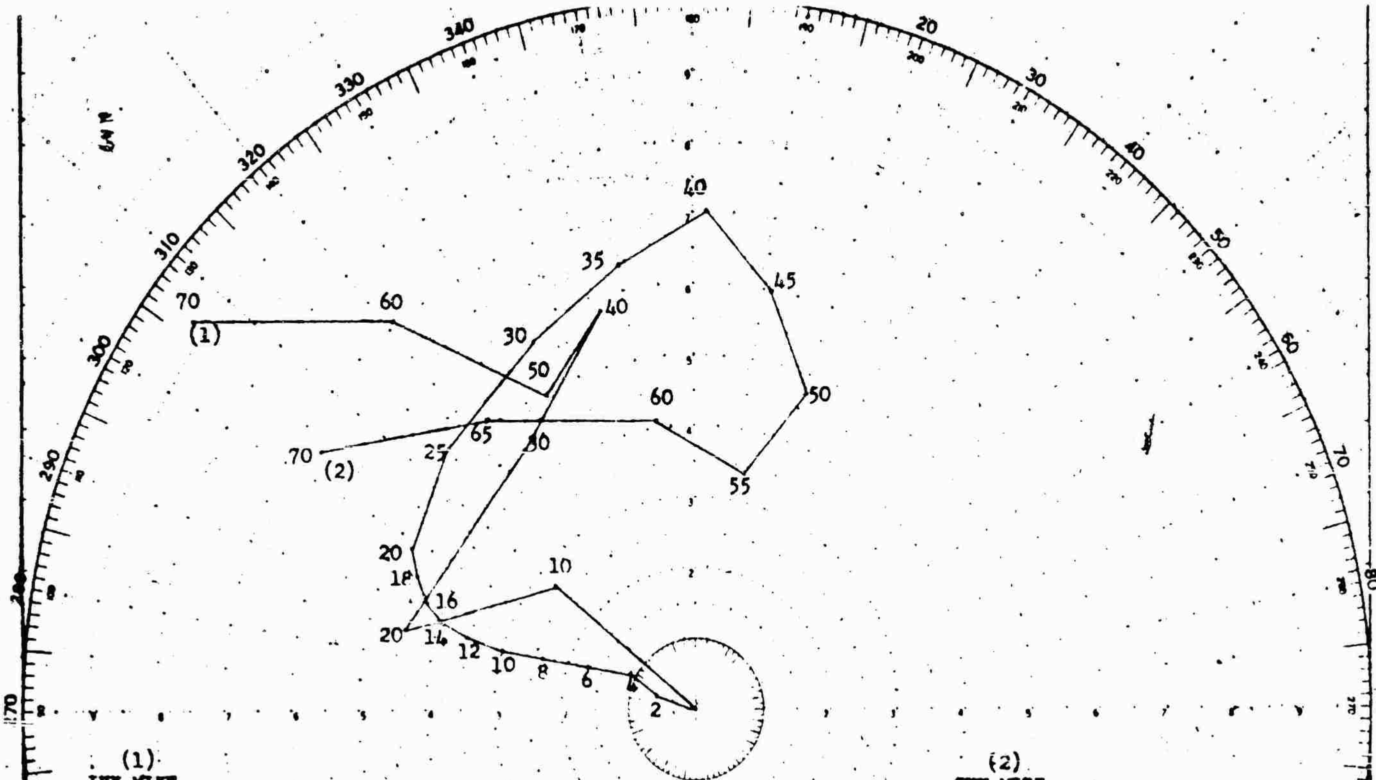
LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0818	0818	0817	0717	Missing
2000	0921	0819	0614	0717	0914
4000	0923	0916	0918	0815	1014
6000	0923	1012	0712	0508	0808
8000	3309	3607	0203	2505	3503
10000	3210	3106	3108	3209	3015
12000	2913	3010	2909	2913	3315
14000	3013	3010	3213	3209	3010
16000	3217	3212	3115	3317	3010
18000	3112	3109	2911	3108	3114
20000	3016	3020	3019	3017	2917
25000	2123	2327	2524	2425	2524
30000	2325	2429	2529	2533	2529
35000	2431	2533	2441	2444	2647
40000	2439	2541	2448	2644	2544
45000	2439	2540	2642	2541	2644
50000	3632	2736	2631	2638	2780
55000	3210	3013	3406	2718	3511
60000	3410	3504	2203		
65000	2703	0503	0914		
70000	3003	0918	0913		
75000		0926	0911		
80000		0822			
85000		0937			
90000		0739			
95000		0845			


ENIWETOK
BIKINI
RONGERIK
KWAJALEIN
MAJURO
PONAPE
KUSIE
LEGEND
X = +12
● = +24
○ = +48
◇ = +72
10 THSD
20 THSD
30 THSD
40 THSD
50 THSD
60 THSD
65 THSD
BRAVO FORECAST
AIR PARTICLE TRAJECTORIES
H TO H + 72
ISSUED H - 9
DATA: H - 12 (CURTISS)
H - 15 (GENERALLY)
175E
180
175W
170W
165E
170E
160E
155E



Copy available to DTIC does not permit fully legible reproduction


BRAVO COMPUTED TRAJECTORIES
ISSUED H + 38 HOURS
DATA H + 33
LEGEND
X = + 6
= + 12
= + 18
= + 24
= + 36
= + 48
= + 60
= + 72
10 THSD
20 THSD
30 THSD
40 THSD
50 THSD
60 THSD
BIKINI
ENIWETOK
RONGERIK
KWAJALEIN
MAJURO
PONAPE
KUSIE
155E
160E
165E
170E
175E
180
175W
170W
165W
160W
20N
15N
10N
5N
EQ
5S
10S
K-32



(1)
IVY MIKE

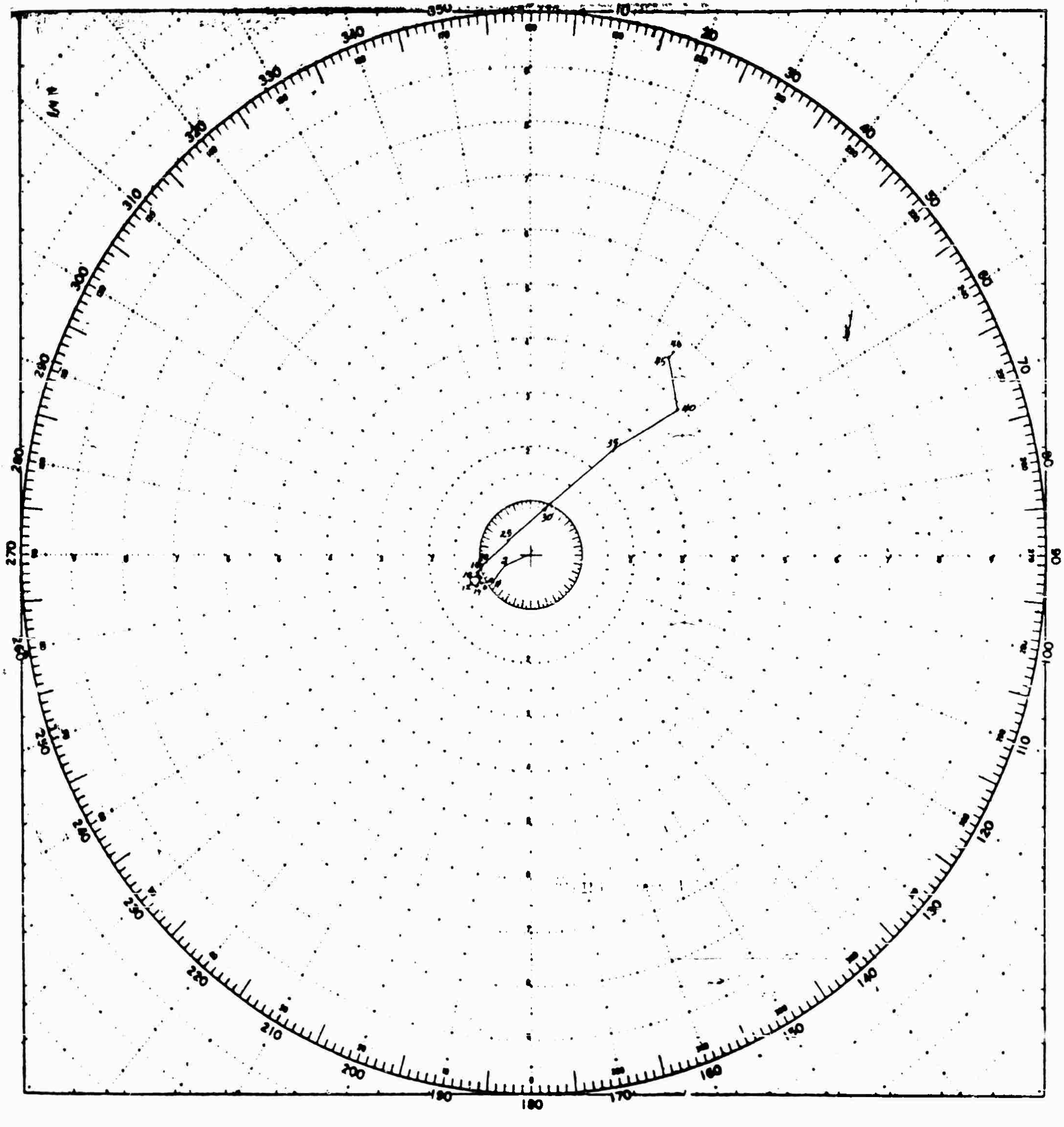
Estimated 010715M November 1952
(From post-shot analysis of 72-hour particle trajectories.)

10,000	130°	13.7 knots
20,000	075°	11.3 knots
30,000	215°	15.5 knots
40,000	210°	11.3 knots
50,000	035°	7.1 knots
60,000	115°	12.5 knots
70,000	090°	15.0 knots

(2)
IVY MIKE

Forecast Winds for 010715M November 1952
(Made at approximately 010300M November 1952)

Surface	070°	17 knots
2,000	110°	15 knots
4,000	130°	12 knots
6,000	100°	15 knots
8,000	100°	17 knots
10,000	100°	15 knots
12,000	110°	14 knots
14,000	120°	10 knots
16,000	140°	10 knots
18,000	160°	10 knots
20,000	170°	10 knots
25,000	200°	15 knots
30,000	220°	20 knots
35,000	230°	17 knots
40,000	240°	18 knots
45,000	320°	15 knots
50,000	340°	15 knots
55,000	040°	15 knots
60,000	120°	15 knots
65,000	090°	25 knots
70,000	080°	25 knots


350
10
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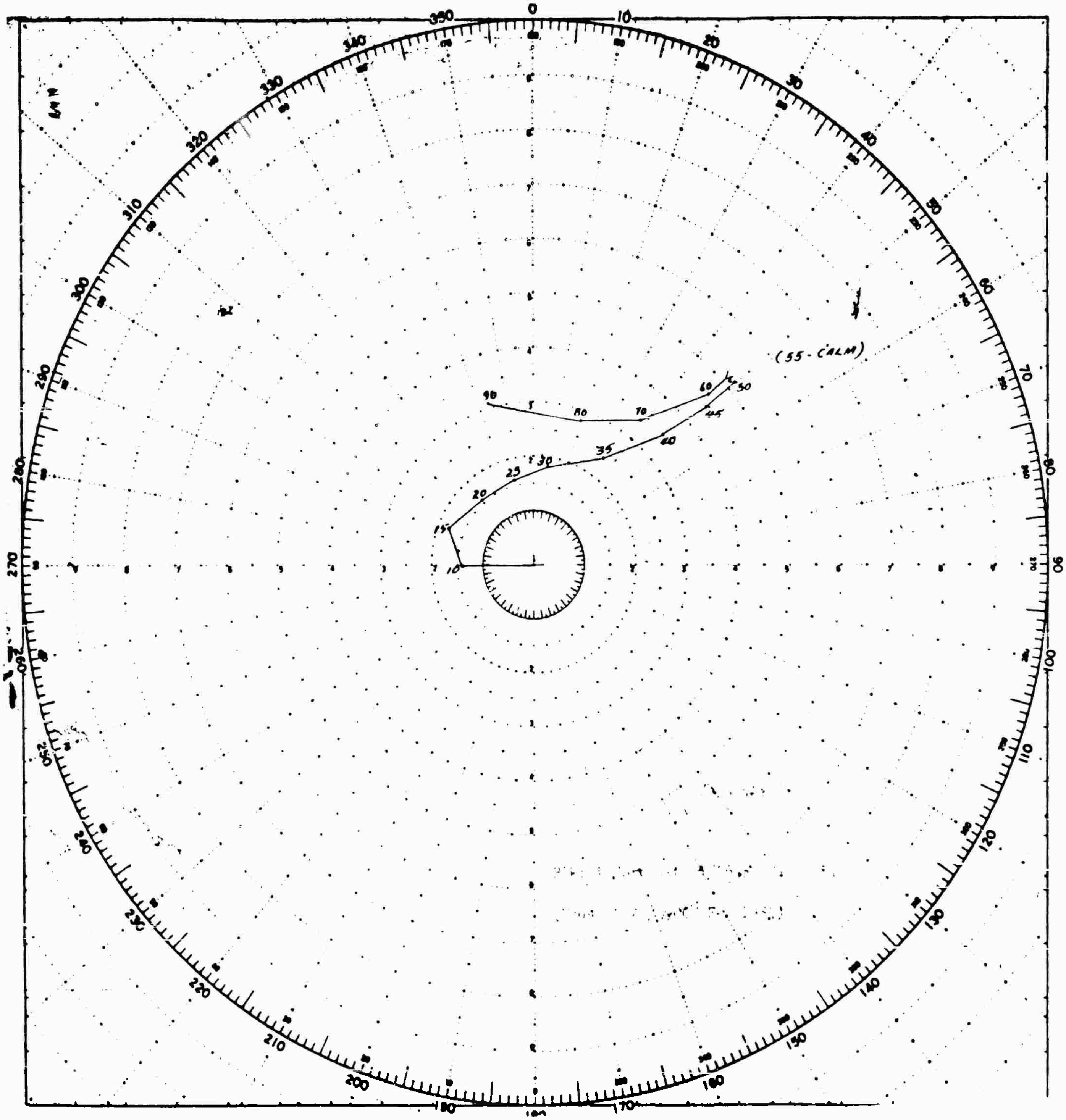
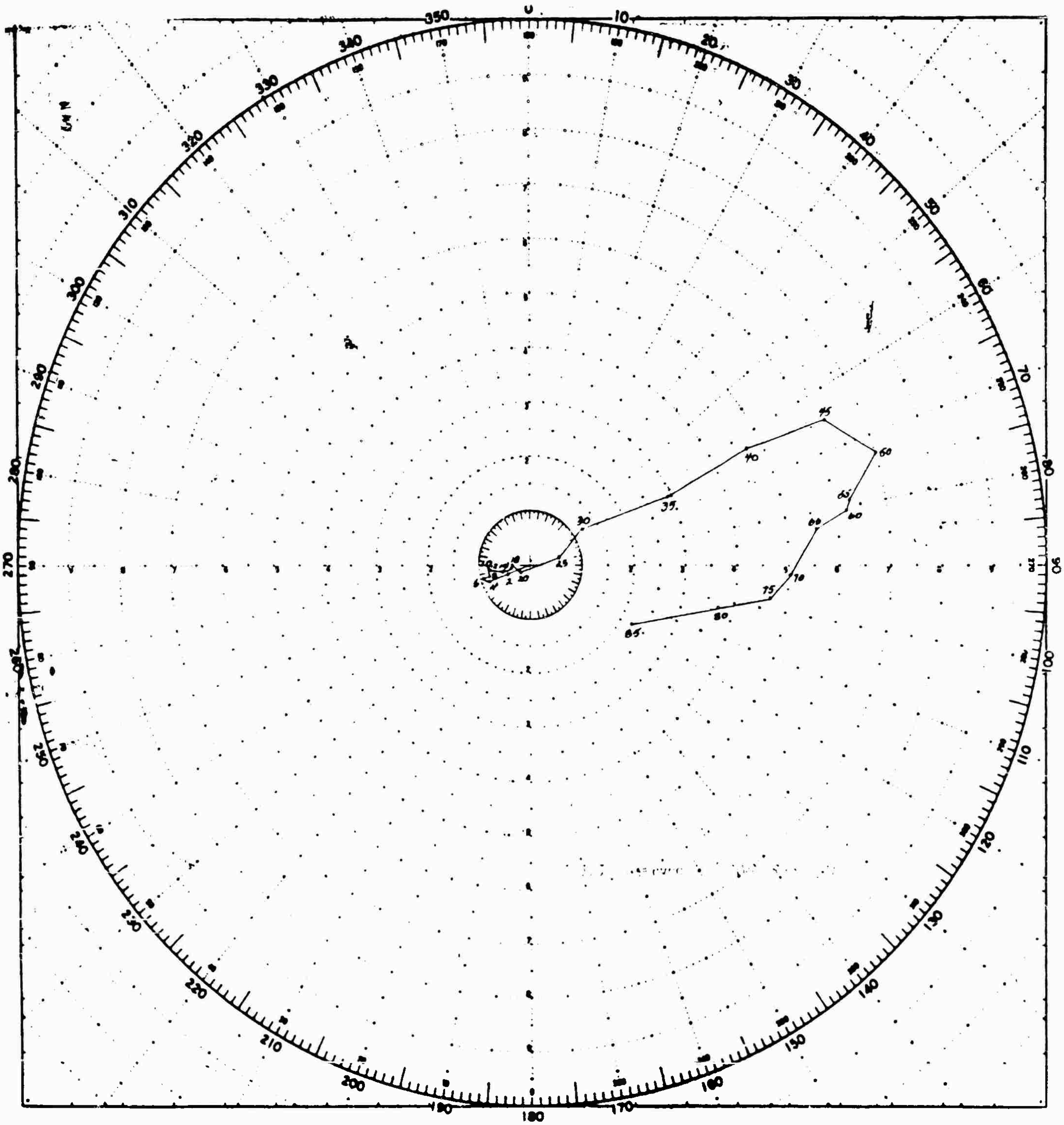
340

K-34



K-35



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220
230
240
250
260
270
280
290
300
310
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350
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35
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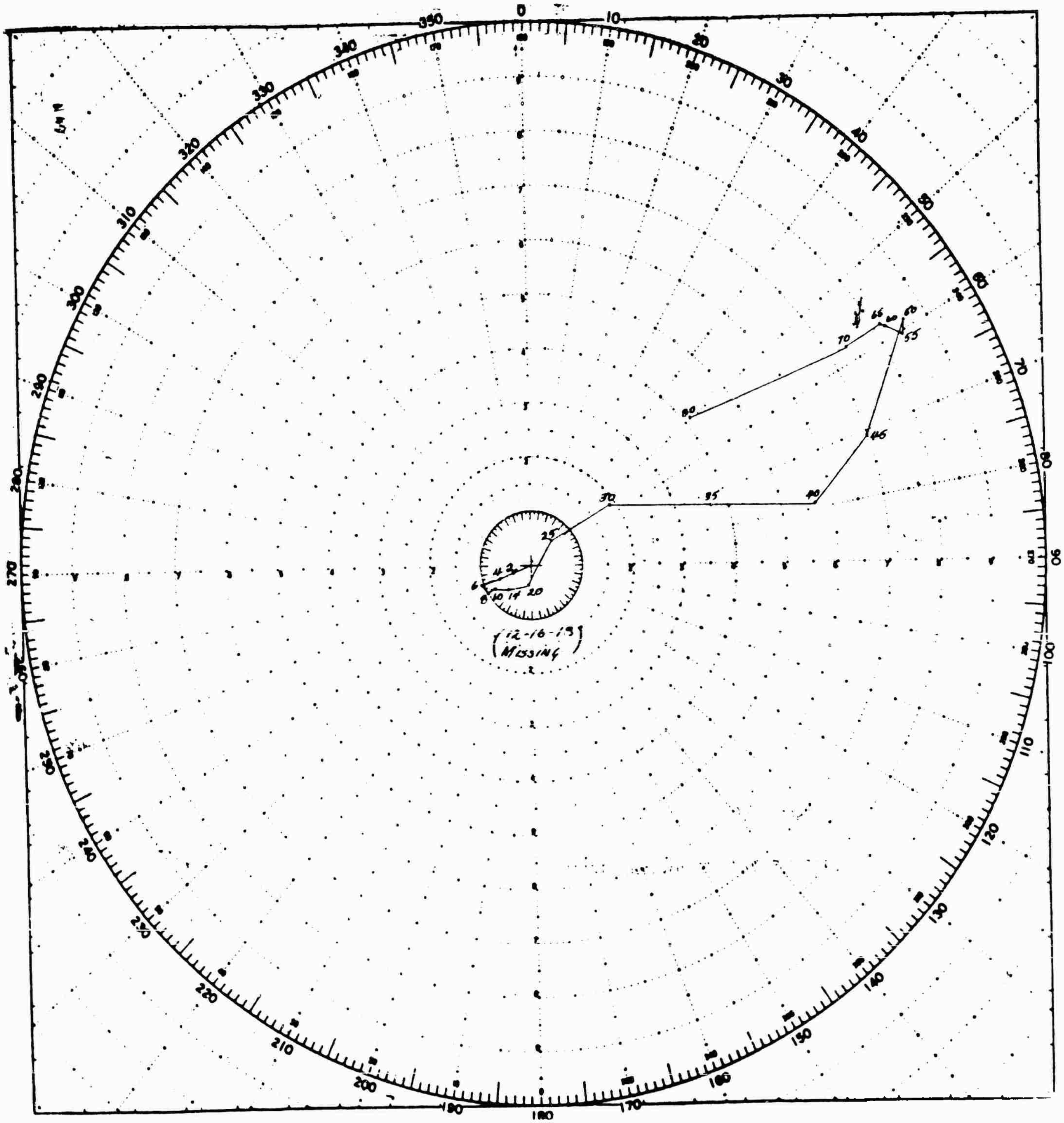
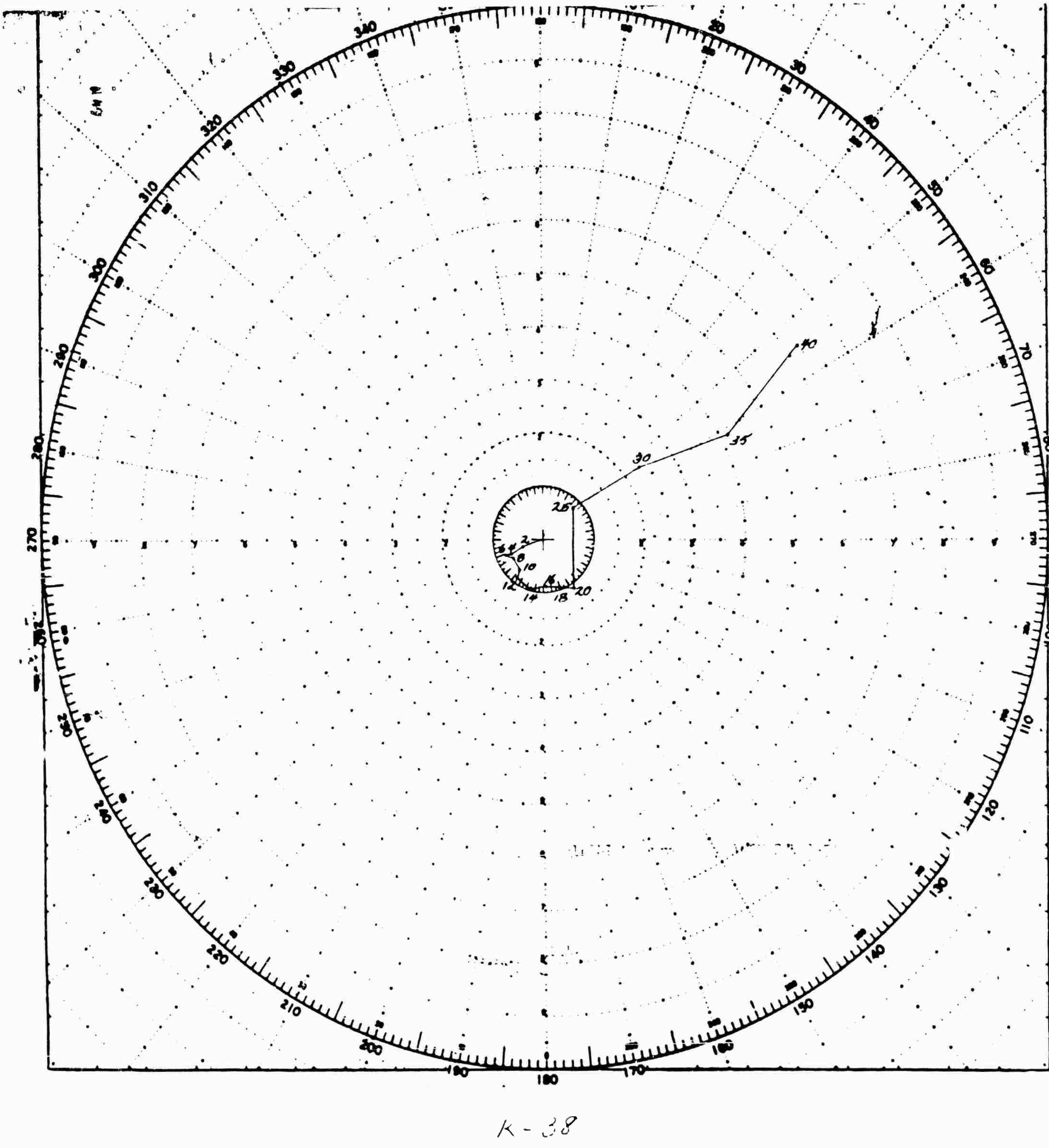
45
60
65
60
69
70
75
80
85

K-36



K-37



340
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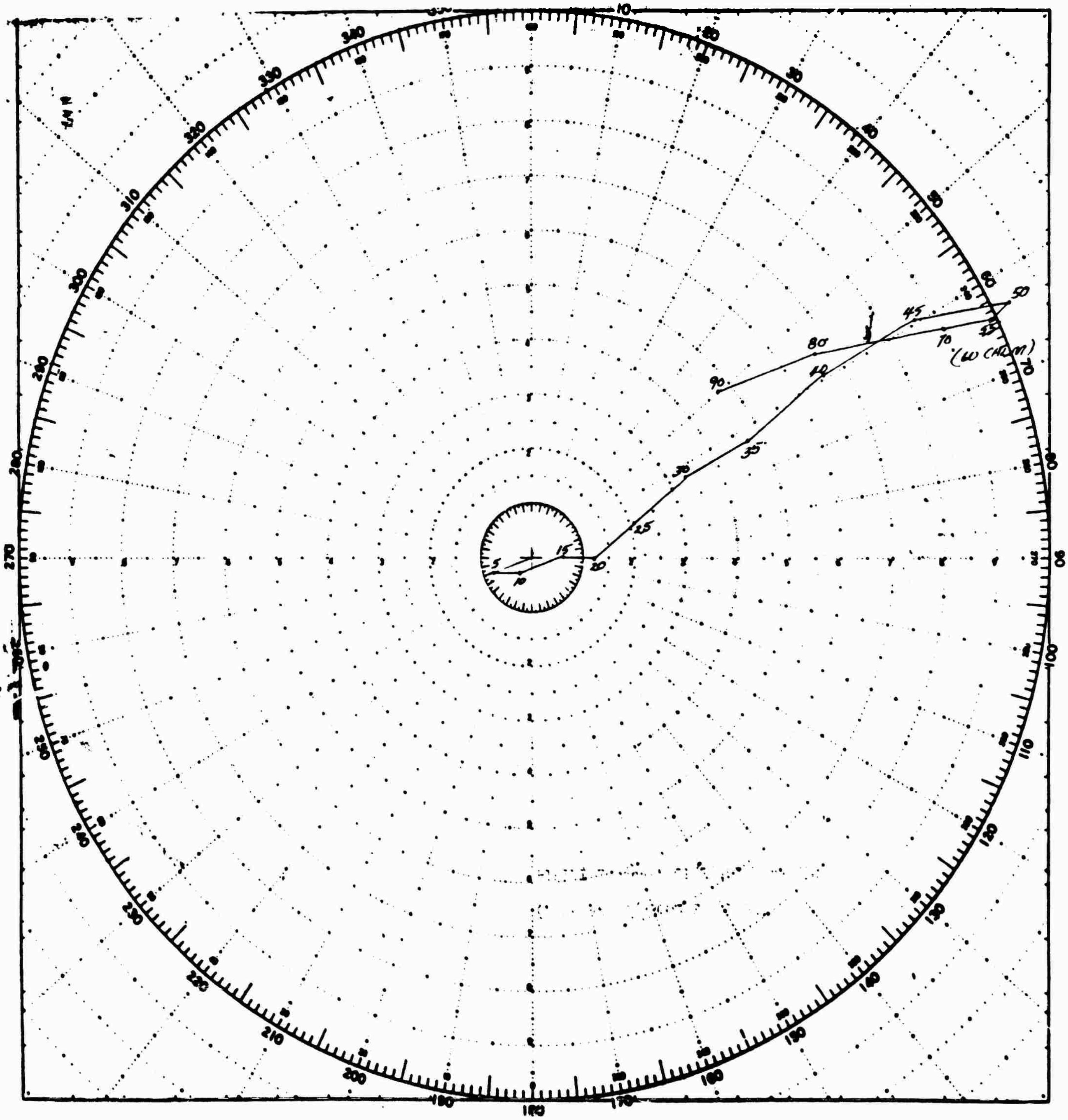
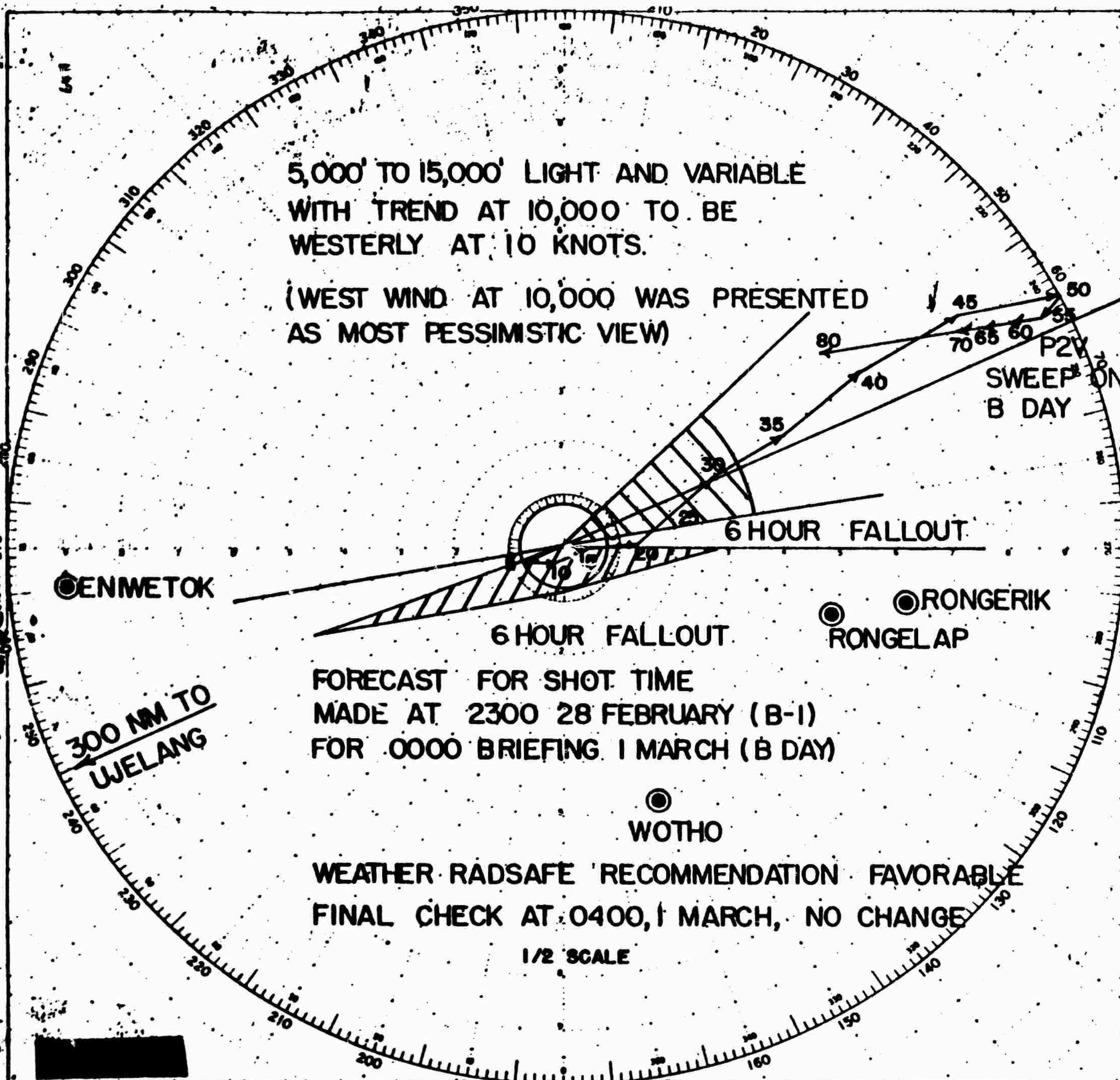
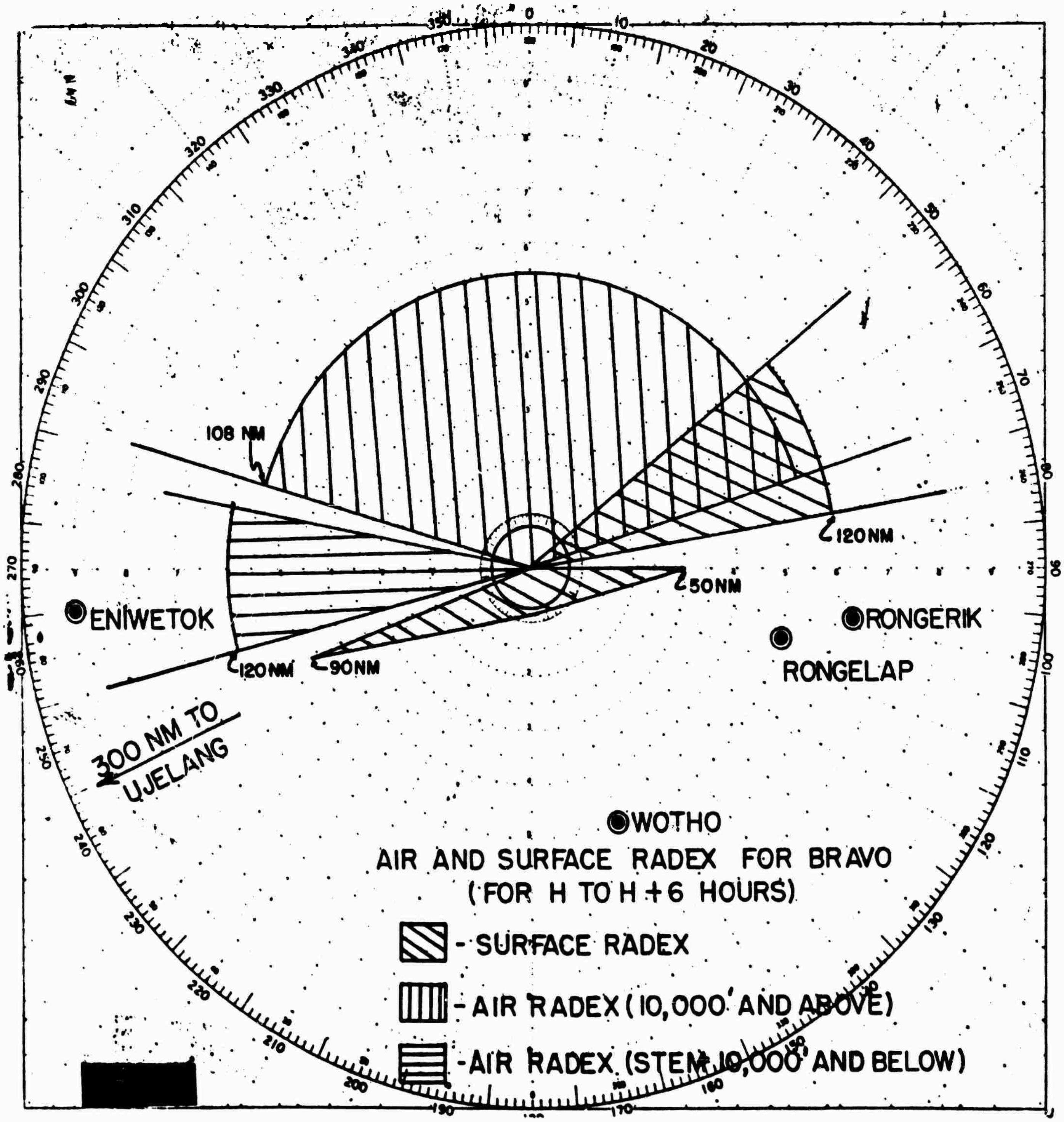
40

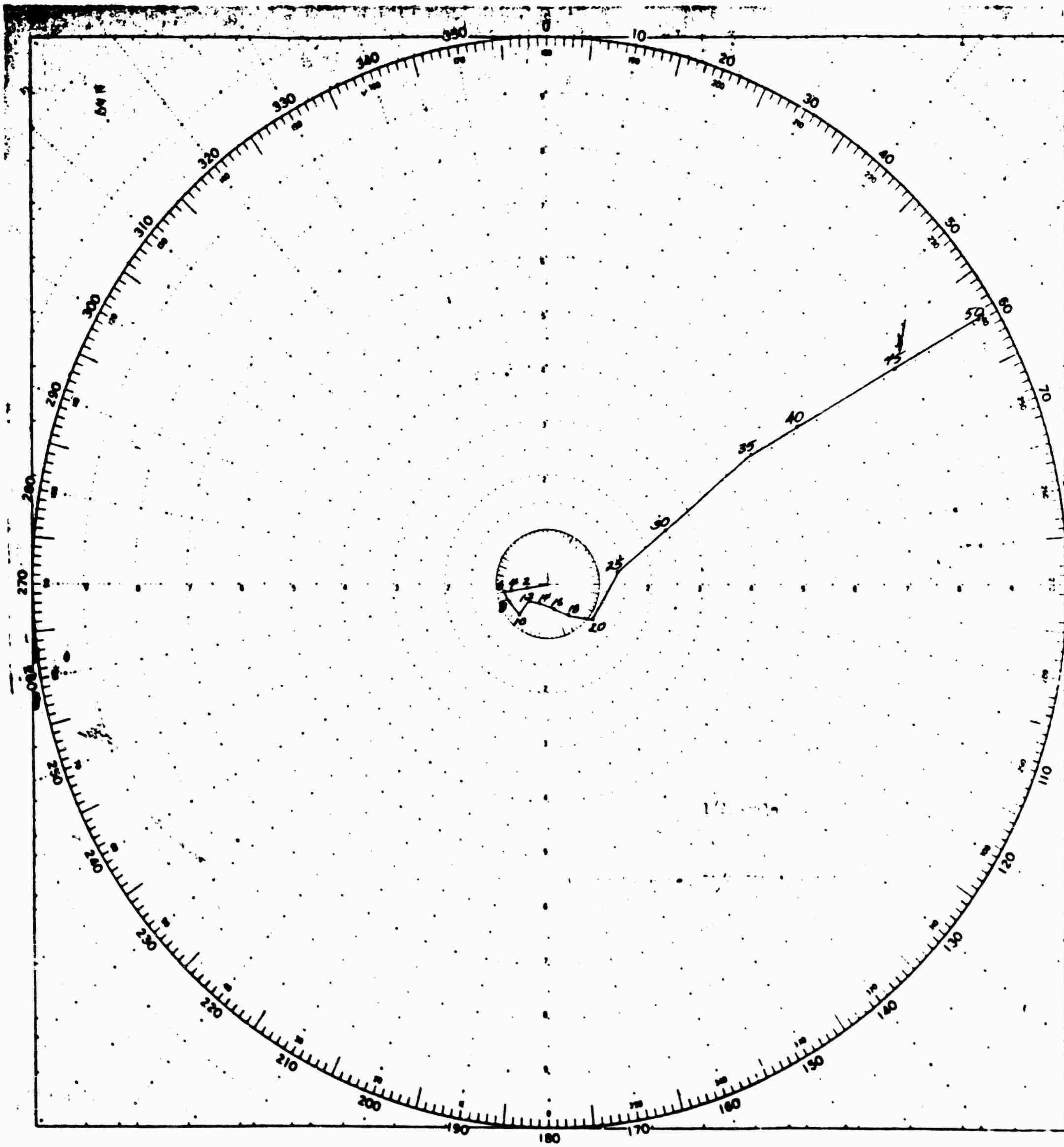
K-38



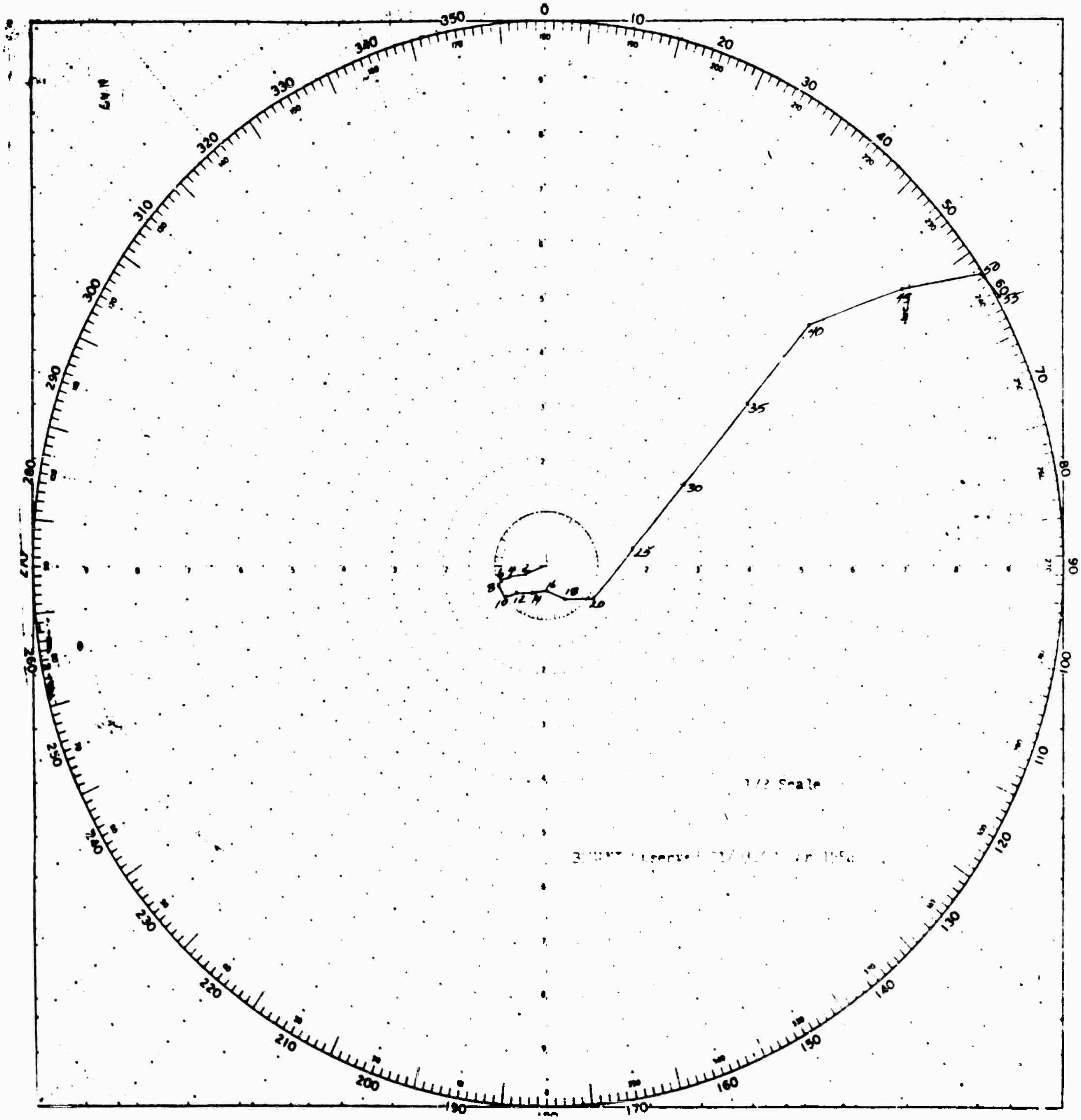
K-39


5,000' TO 15,000' LIGHT AND VARIABLE
WITH TREND AT 10,000 TO BE
WESTERLY AT 10 KNOTS.
(WEST WIND AT 10,000 WAS PRESENTED
AS MOST PESSIMISTIC VIEW)
P2V
SWEEP ON
B DAY
6 HOUR FALLOUT
ENIWETOK
RONGERIK
RONGELAP
6 HOUR FALLOUT
FORECAST FOR SHOT TIME
MADE AT 2300 28 FEBRUARY (B-1)
FOR 0000 BRIEFING 1 MARCH (B DAY)
300 NM TO
UJELANG
WOTHO
WEATHER RADSAFE RECOMMENDATION FAVORABLE
FINAL CHECK AT 0400, 1 MARCH, NO CHANGE
1/2 SCALE
[redacted]

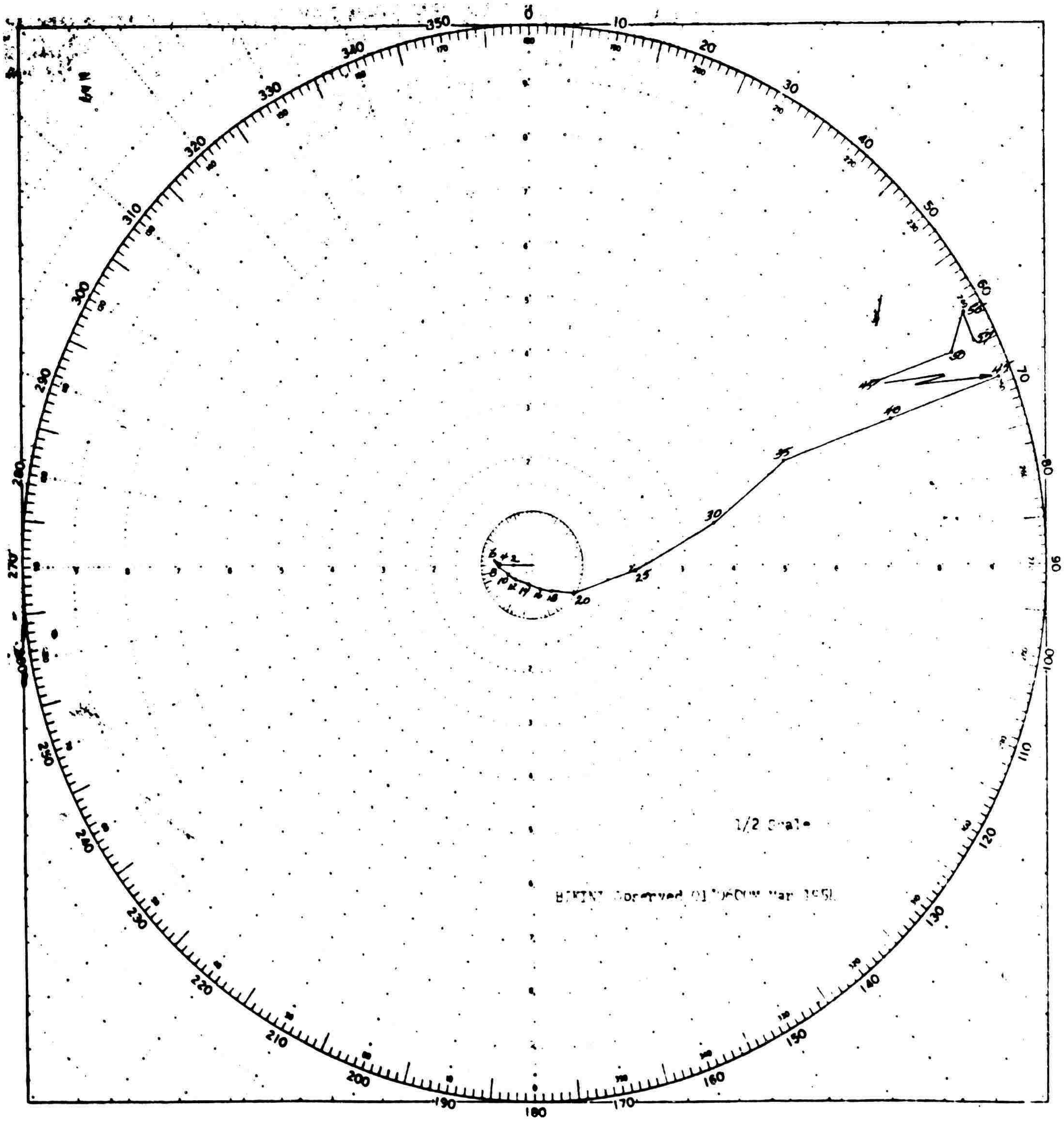

108 NM
120NM
50NM
120NM
90NM
ENIWETOK
RONGERIK
RONGELAP
300 NM TO
UJELANG
WOTHO
AIR AND SURFACE RADEX FOR BRAVO
(FOR H TO H+6 HOURS)
- SURFACE RADEX
- AIR RADEX (10,000' AND ABOVE)
- AIR RADEX (STEM 10,000' AND BELOW)



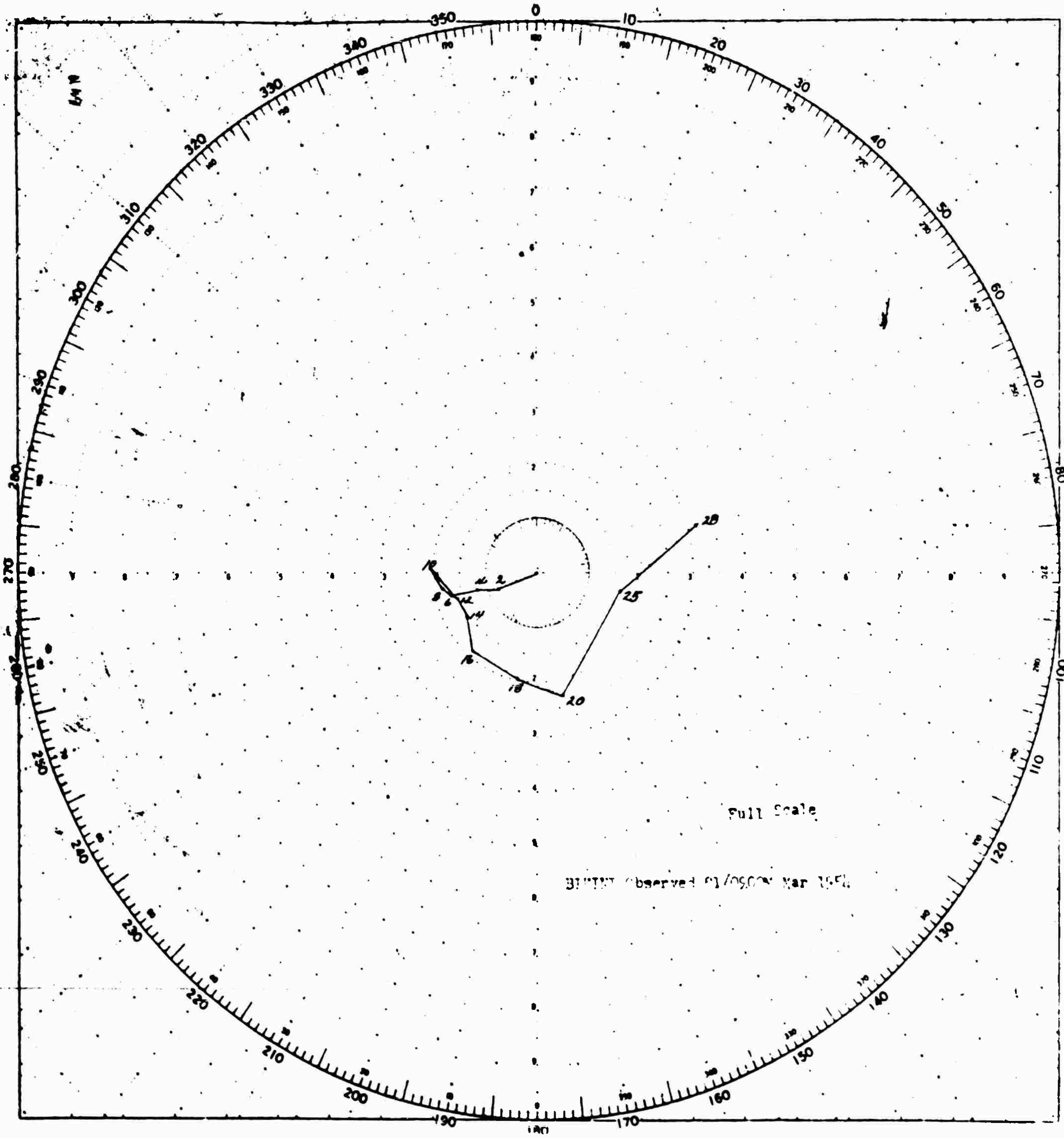
K-42



K-43



K-44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220
230
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250
260
270
280
290
300
310
320
330
340
350
Full Scale
Observed
Mar

AIR RADSAFE OPERATIONS FOR BRAVO

8 March 1954

1. SUMMARY:

The BRAVO Air Rad Safe Operations were conducted essentially as planned. The BRAVO cloud reached an altitude on the order of 120,000 feet. No hazardous air contaminations were encountered by aircraft other than the samplers. Several aircraft and crews were exposed but the levels encountered appear acceptable from a health and decontamination aspect. Communication and control difficulties made it difficult if not impossible to detect the fall-out in the RONGERIK/RONGELAP areas. The defects which became apparent during BRAVO operations have been remedied.

2. GENERAL:

Cloud tracking information for BRAVO was derived from five sources. The manner in which each of these functioned during BRAVO will be discussed individually in subsequent paragraphs. These sources were as follows:

Sampling aircraft Reports
Sweet-Sour Reports
Special Cloud Tracking Flights
Weather Reconnaissance Flights
AFOAT-1 Flights

3. SAMPLING AIRCRAFT REPORTS:

These reports were monitored and recorded by Rad Safe personnel aboard the Command Ship from plus two through plus seven hours. Information derived from these reports indicated the sampling aircraft were working the south and southeast edge of the cloud and therefore stayed in the immediate vicinity of Ground Zero. Because of the altitude of the sampling operations (30,000 - 45,000 ft) there is little relation between the operation of these aircraft and subsequent air or ground contamination. This data, however, does assist the Air Rad Safe Officer in obtaining an overall picture of the dispersal of radioactive material.

4. SWEET-SOUR REPORTS:

These reports are submitted by any aircraft encountering radioactive contamination and not reporting by other means. No such reports were received during BRAVO. This is not surprising since aircraft other than the samplers and trackers (reporting by other means) seek to avoid areas in which contamination is suspected.

INCLOSURE #6

5. SPECIAL CLOUD TRACKING (WILSON) FLIGHTS:

a. The first of these flights, Wilson 2, was instructed by Rad S. to fly a 10,000 holding pattern track approximately 50 miles west of Ground Zero from plus two to plus five hours. Unfortunately instructions were subsequently given Wilson 2, without Rad Safe coordination, authorizing Wilson 2 to remain in the holding pattern. In this area at 10,000 feet the activity encountered never exceeded 15 mr/hr. When the Rad Safe realized that Wilson 2 had overstayed in the holding pattern, the Air Operations Center (AOC) was requested to order him into the previously designated search sector at once. (The sector was centered on GZ, limiting bearings 55 and 85 degrees true to 500 NM at 10,000 feet.) The delay, however, resulted in this aircraft being well behind and to the north of the cloud segments that must have caused fall-out on RONGERIK and RONGELAP. At 1550M the aircraft reported its maximum reading during its flight. This was reported as being between 500 and 1000 mr/hr approximately 150 nautical miles from Ground Zero at a bearing of 60 degrees. (See attached plot.) This and the subsequent data appeared to verify the forecast cloud trajectories which indicated the upper cloud segments would leave the PPG on an approximate bearing of 70 degrees, thus avoiding the populated atolls. Wilson 2 subsequently reported in-flight difficulty with the instruments used.

b. On the basis of the results of the Wilson 2 flight the second tracker, Wilson 3, was instructed to search the same general area but to proceed further east to define the rate of cloud movement. Wilson 3 was directed to search the sector centered on RONGERIK, limiting true bearings 50 and 80 degrees to 500 NM at 10,000 feet, thence to 17N, 163E to base. At approximately 2000M hrs information was received indicating the possibility of some contamination in the RONGERIK/RONGELAP area. A message was immediately dispatched to TG 7.4 requesting Wilson 3 to alter his search area in such a manner as to cover the populated atoll area to the east. Communication delays prevented Wilson 3 from receiving the request in time to comply. This plus the fact that no exact instrument readings (instead a range of readings) were reported made interpretation of cloud tracking data difficult.

c. Subsequent Wilson flights (for plus one day) were cancelled when it appeared that no air contamination problem existed at that time.

d. The 10,000 foot flight levels for the Wilson aircraft had been picked to assure survey in the lowest shear level and thus avoid overly complicated and less reliable analysis of ultimate cloud movement which would arise from higher level surveys.

6. WEATHER RECONNAISSANCE FLIGHTS:

Two Petrel Juliet Weather reconnaissance flights were flown on BRAVO plus one day. These flights (see attached plot), flown to the south and to the southeast, indicated essentially zero air contamination.

7. AFOAT-1 FLIGHTS:

AFOAT-1 sponsored flights from Hawaii indicated a maximum air contamination of less than 1 mr/hr in that area (3 March). Similar flights from Guam reported tenths of an mr/hr as a maximum reading. This was encountered 4 March, 100 nautical miles west of Ponape at 5000 ft.

8. INFLIGHT EXPOSURES:

As expected, several aircraft, including samplers, cloud trackers, evacuation aircraft and P2V security sweep aircraft, encountered areas of air contamination. In all cases it appears that the exposures were well under task force limitations for a health point of view. Standard decontamination procedures are expected to be effective so that all aircraft should be returned to service well prior to the next shot.

9. CONCLUSIONS:

a. The air Rad Safe operations for BRAVO were generally successful but several changes in procedures are being made (see below) to provide more timely and accurate data.

b. No hazardous areas of air contamination were encountered although fall-out in the RONGERIK/RONGELAP area would make it probable that such contamination did exist for a short period over or near those atolls.

c. Improved monitoring, data reporting and communication facilities are required.

d. Lower search altitudes may improve the ability to correlate air contamination with subsequent fall-out.

e. No hazardous fall-out appears likely in the Hawaii, Ponape or Guam areas.

f. In flight exposures of Task Force personnel were well within established limits.

10. RECOMMENDATIONS:

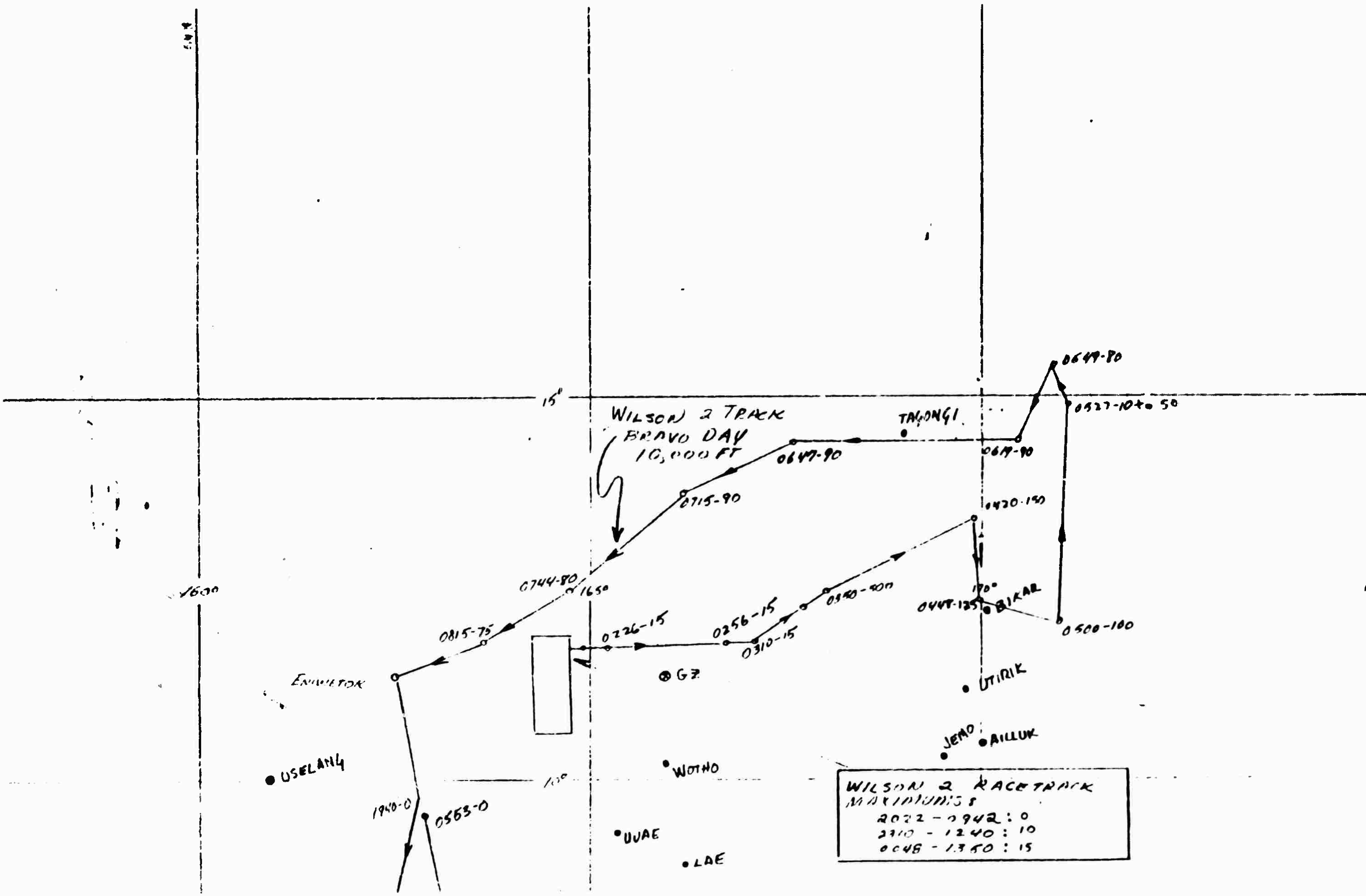
a. A CW contact is required between the Command Ship and the Wilson aircraft to insure better data reporting and control. (Note: An additional two-way CW station was subsequently located in the Radsafe Office, the station tied into the Wilson/Eniwetok AOC net.)

b. Exact radiation readings should be reported. (Note: A slight chance in the reporting system was devised to resolve this problem.)

c. Pre-BRAVO requirements that all Wilson aircraft carry a spare radiac instrument of the AN/PDR TIB type should be given high priority. (Note: Spares were carried on all subsequent shots.)

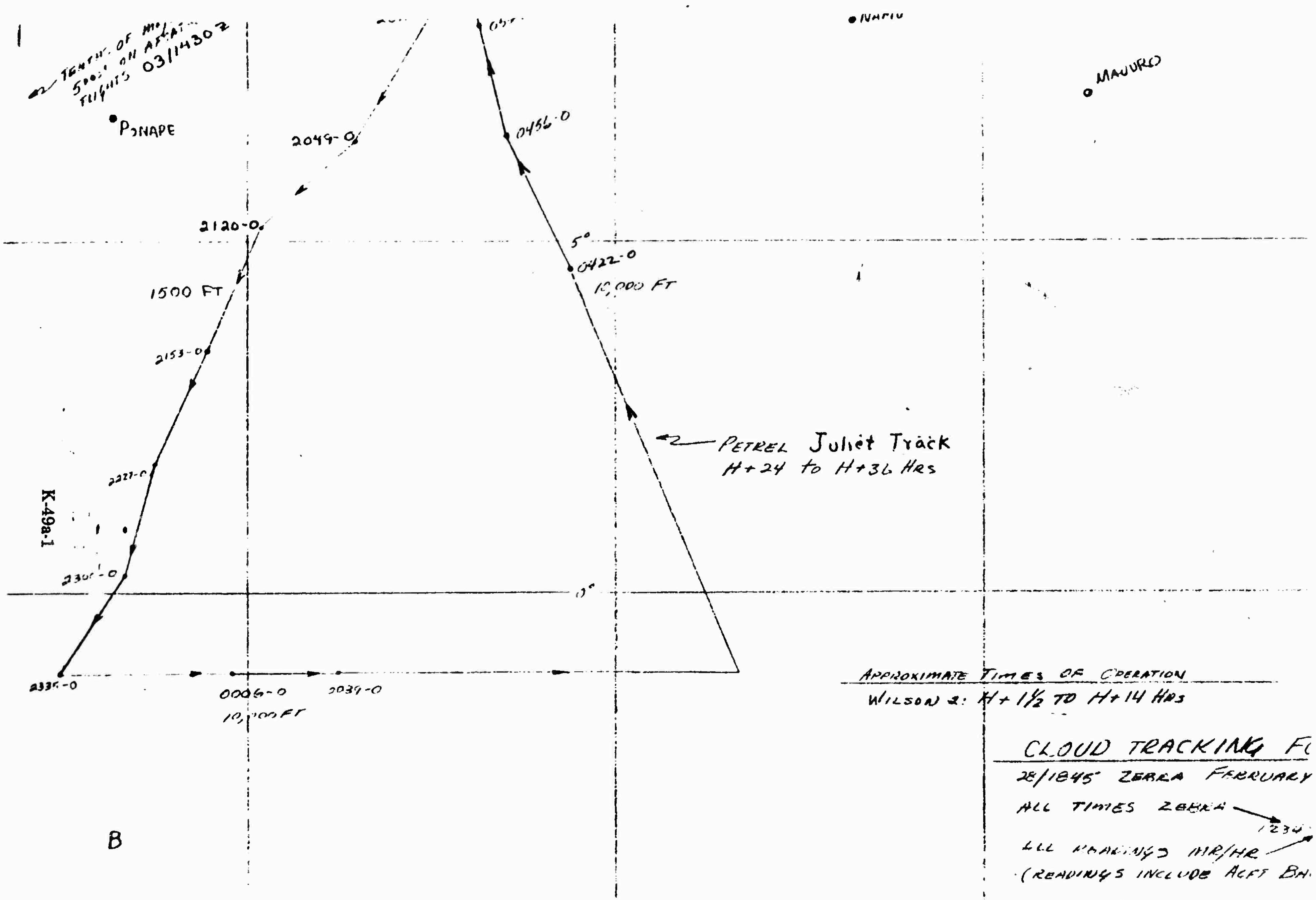
d. The desirability of employing lower altitudes in tracking operations should be investigated on subsequent shots. (Note: Some of the work was successfully performed at 5,000, 1,500 and below 1,000 feet on subsequent shots.)

1 Appendix:
I Wilson A/C Plot (A & B)

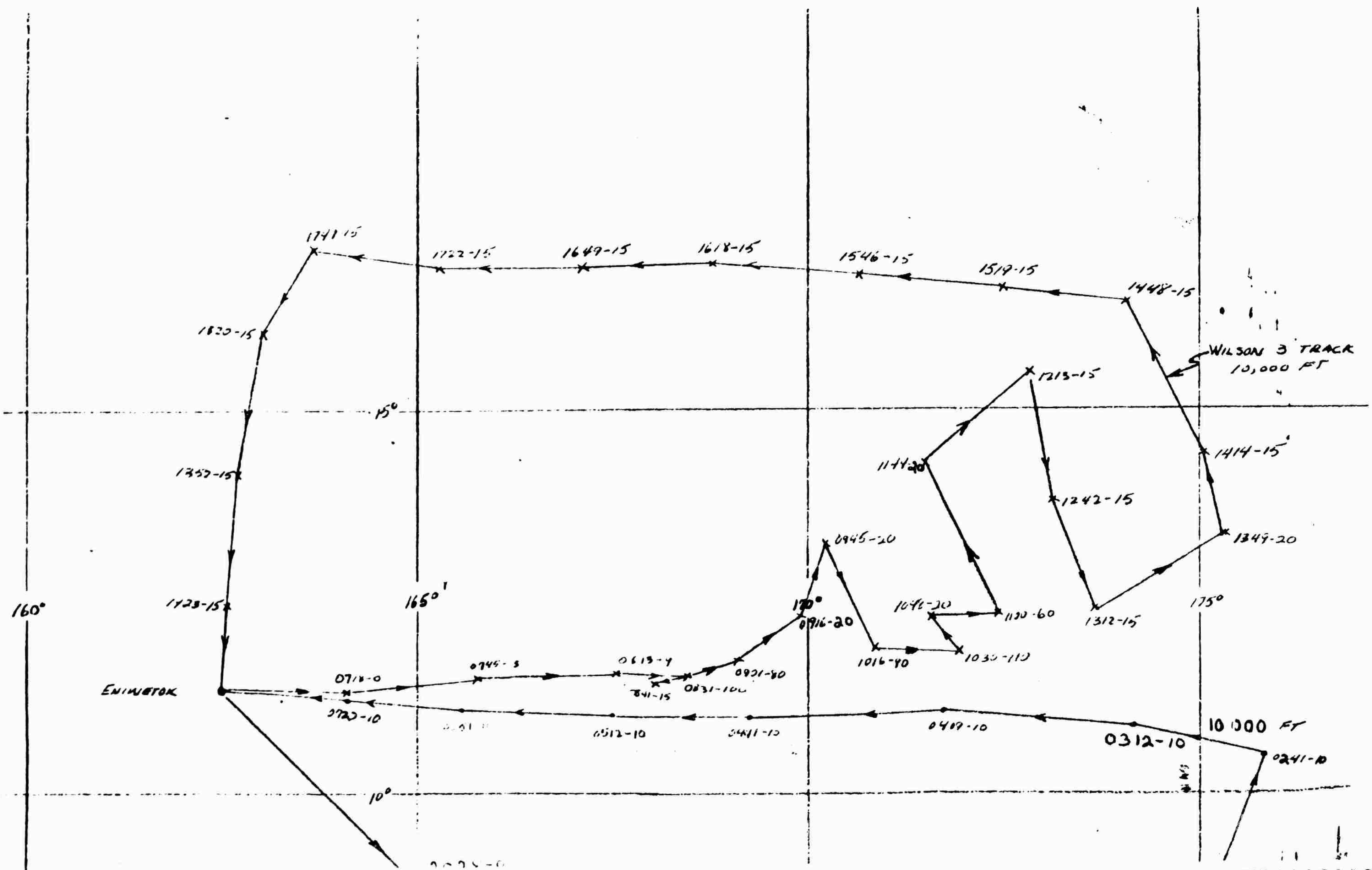


WILSON 2 TRACK
BRAVO DAY
10,000 FT
WILSON 2 RACETRACK
MAXIMUMS
2022 - 0942 : 0
2310 - 1240 : 10
0048 - 1350 : 15
160°
165°
170°
175°
15°
10°
ENIWETOK
USELANG
UJAE
LAE
WOTHO
GZ
UTIRIK
JEMO
AILUK
BIKAR
TAONGI
1940-0
0553-0
0815-75
0744-80
1650
0715-90
0647-90
0619-90
0649-80
0527-10 to 50
0500-100
0420-150
0448-135
0350-200
0310-15
0256-15
0226-15

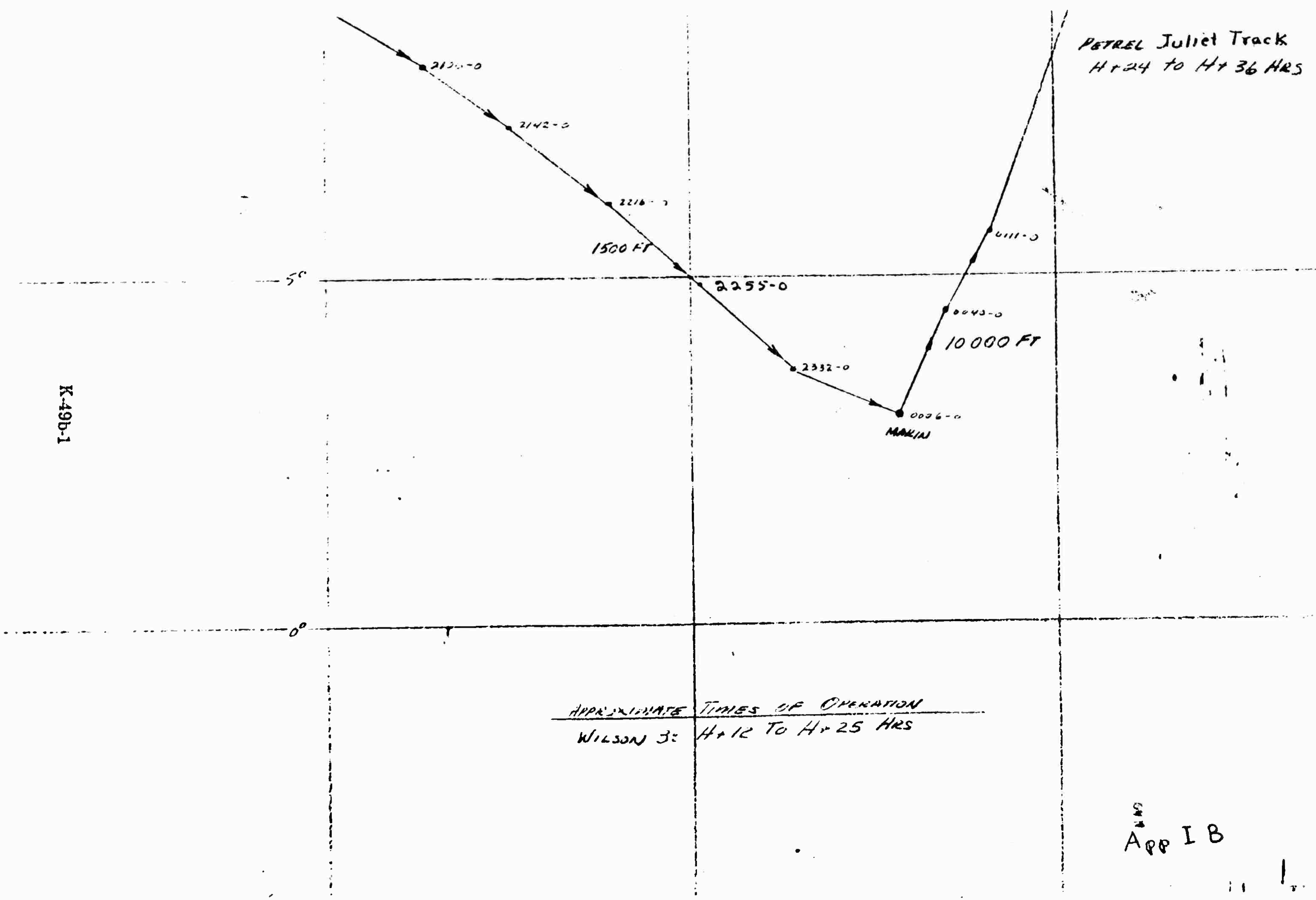
K-49a


TENTH OF MR. 500 ON AFT FLIGHTS 031430Z
PONAPE
MAJURO
2049-0
2120-0
1500 FT
2153-0
2221-0
2301-0
2335-0
0006-0
10,000 FT
2039-0
0456-0
5°
0422-0
10,000 FT
0°
PETREL Juliet Track
H+24 to H+36 Hrs
APPROXIMATE TIMES OF OPERATION
WILSON 2: H+1½ TO H+14 HRS
CLOUD TRACKING F
28/1845 ZEBRA FEBRUARY
ALL TIMES ZEBRA
1234
ALL READINGS MR/HR
(READINGS INCLUDE ACFT B
B

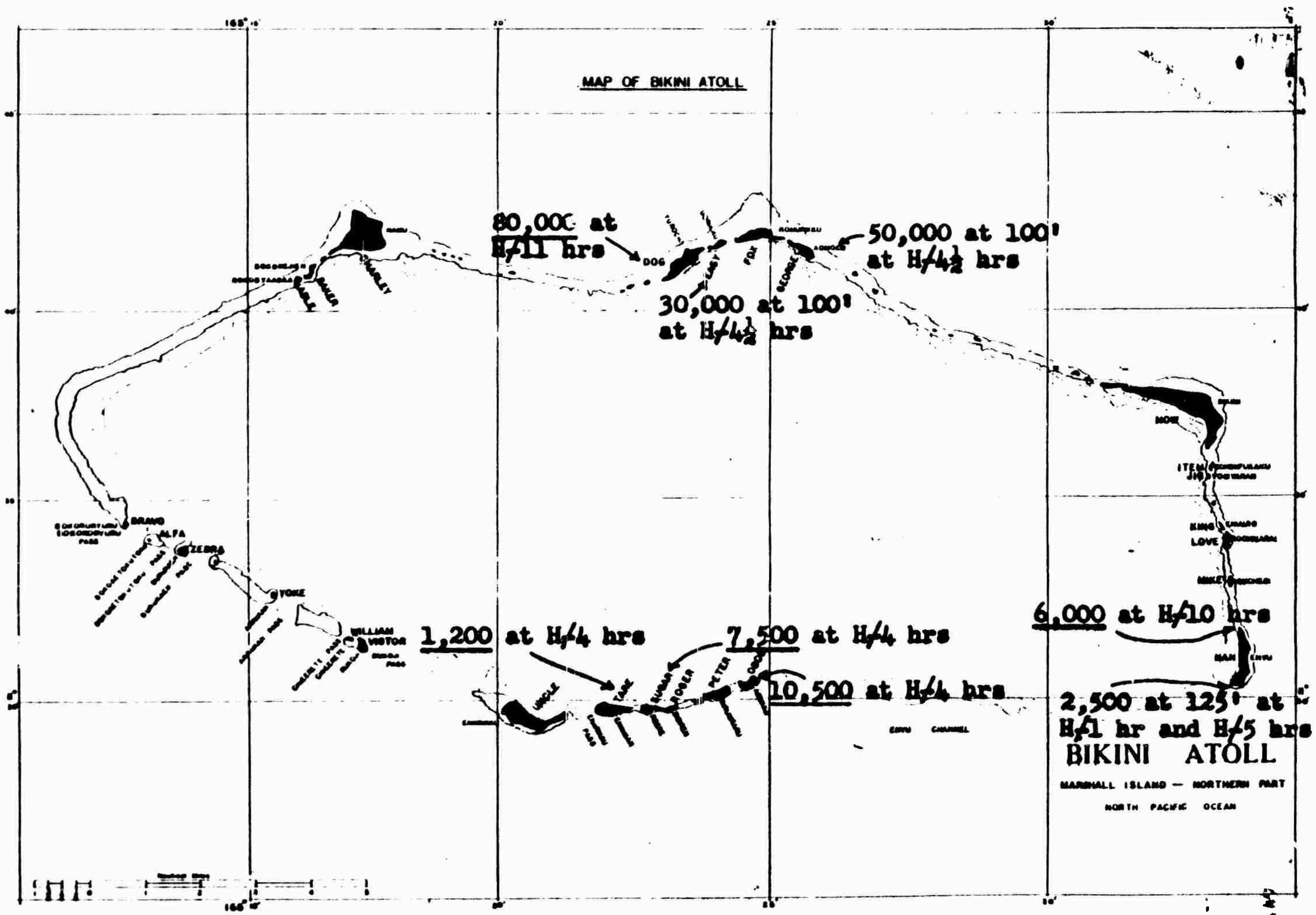
K-49a-1


WILSON 3 TRACK
10,000 FT
10 000 FT
0312-10
0241-10
0407-10
0411-10
0512-10
0720-10
0718-0
0745-5
0813-9
841-15
0831-100
0901-80
0916-20
0945-20
1016-40
1030-110
1040-20
1130-60
1144-20
1213-15
1242-15
1312-15
1349-20
1414-15
1448-15
1519-15
1546-15
1618-15
1649-15
1722-15
1741 15
1820-15
1357-15
1423-15
ENIWETOK
160°
165°
170°
175°
15°
10°

K-496

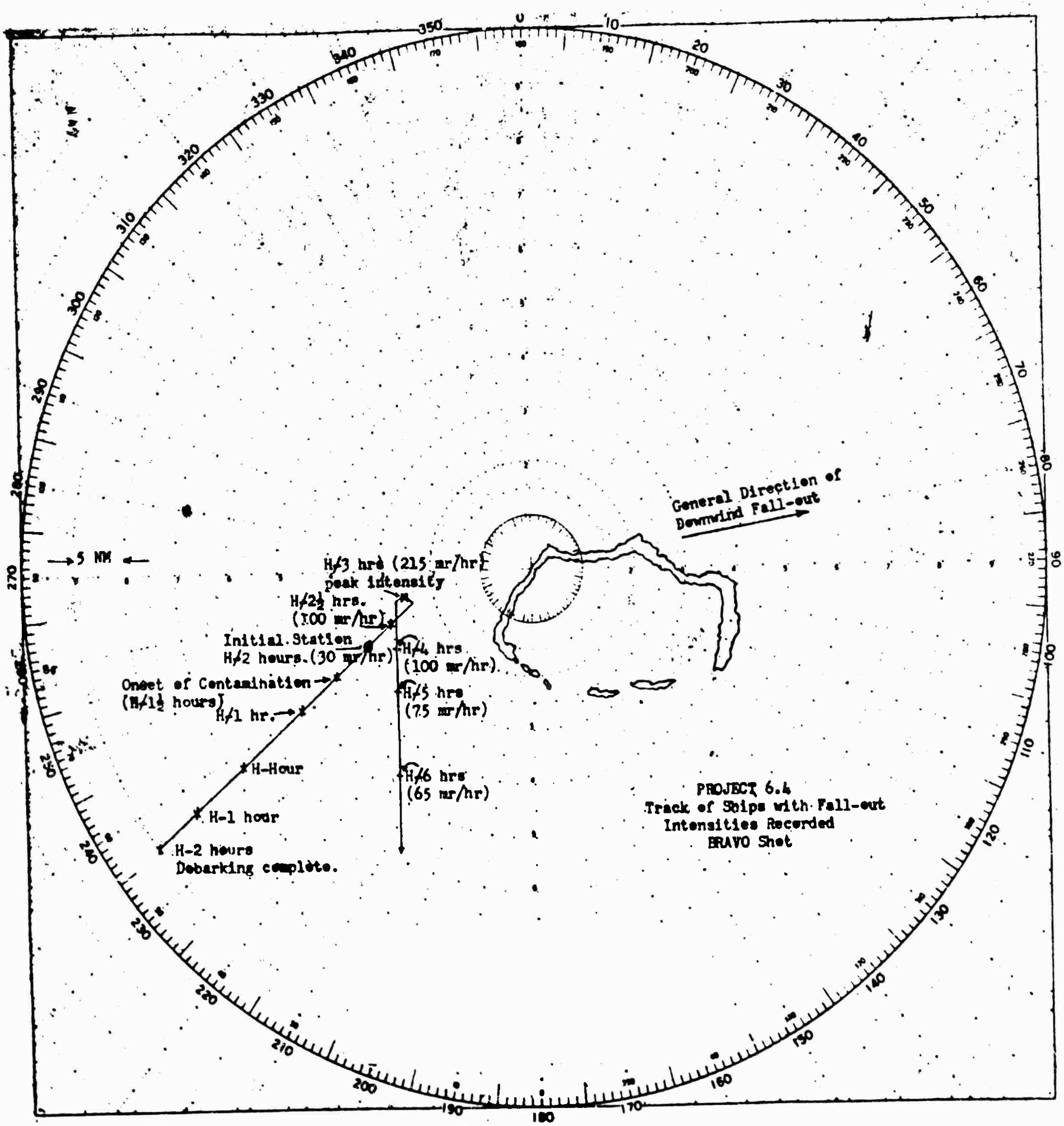

PETREL Juliet Track
H+24 to H+36 HRS
2255-0
2332-0
0006-0
MAKIN
0043-0
10 000 FT
0111-0
2142-0
2216-0
1500 FT
5°
0°
APPROXIMATE TIMES OF OPERATION
WILSON 3: H+12 TO H+25 HRS

App I B



Radsafe Survey Readings BRAVO Day
(All readings in mr/hr; ground readings underlined.)

K-49c



PROJECT 6.4
Track of Ships with Fall-out
Intensities Recorded
BRAVO Shot

k-49d

JOINT TASK FORCE SEVEN
TASK GROUP 7.3
APO 187, c/o Postmaster
San Francisco, California

FF3/7.3/32:mf
J15-9
Ser: 00664

22 March 1954

From: Commander, Task Group 7.3
To: Chief of Naval Operations
Via: (1) Commander Joint Task Force SEVEN
(2) Commander in Chief, U.S. Pacific Fleet

Subj: Radioactive Contamination of Ships and Radiological Exposure of Personne of Task Group 7.3 due to BRAVO, the First Nuclear Explosion of CASTLE

Ref: (a) CTG 7.3 Conf dispatch 130733Z of March 1954

Encl: (1) Diagram indicating positions of TG 7.3 ships from H hour until about 0815, 1 March 1954.
(2) Tabulation of average topside radioactive intensities of Task Group 7.3 ships, at various times following BRAVO.
(3) Tabulation of accumulated radiological exposures of Task Group 7.3 personnel by ships and units.
(4) BAIROKO (CVE 115) secret serial 0010 of 11 March 1954.

1. On 1 March 1954, at 0645M, the first nuclear explosion (BRAVO) of Operation CASTLE was detonated. Prior to the detonation, ships of Task Group 7.3 had been deployed at sea generally in the southeast quadrant from ground zero as indicated in enclosure (1). This disposition and its location were based on four principal factors, (a) the latest CJTF SEVEN radex, (b) the requirements of the Commander Scientific Task Group (CTG 7.1) that ESTES (AGC 12) and CURTISS (AV 4) be positioned about 12 miles from ENYU Island for reliable UHF communications and Raydist purposes, (c) the requirement that ships be disposed at safe distances (at least 30 miles) from ground zero to avoid harmful heat, and blast effects, and (d) the requirement of reasonable concentration for communications and control purposes. Prior to the detonation and because later wind data began to indicate an easterly component, some of the smaller and slower units were directed to move to the south, but the larger ships were retained in the localities indicated in view of the foregoing requirements (b) and (d) and the expressed desire of the JTF Commander that they not be moved. Because of the additional requirements for early helicopter survey trips and the early dispatch by helicopter of an emergency airfield crew for the airfield on ENINMAN Island, the large ships were retained generally in their pre-shot positions after the detonation until about 0800M, when sudden and rapidly increasing radioactive fallout was detected on some ships. At this time, all ships were ordered to take all possible radiological defense damage control measures, including the employment of washdown systems, and to proceed to the south at best speed.

SRD-229-54E

2. Commencing about 0800M, highly radioactive, visible, white particles, about the size of pinheads, began to fall on BAIROKO, PHILIP, ESTES and CURTISS. At this time BAIROKO was about 31 miles from ground zero. In spite of the continuous use of their washdown systems, concentrations of up to several roentgens per hour built up on BAIROKO and PHILIP (plane guard for BAIROKO), with average readings reaching 500 and 750 milliroentgens per hour, respectively. The fallout pattern was not symmetrical, since both ESTES and CURTISS, approximately the same distance from ground zero as BAIROKO but on opposite sides of her, received less contamination. Other ships, including those which had been moved southward before the detonation, received none of this early fallout.

3. In addition to the early heavy fallout encountered by some ships during the morning, in the afternoon and early evening of 1 March, light, invisible fallout was detected by all ships in the area. Again, damage control measures were employed by all ships. This fallout commenced about 1300M, reached a maximum about 1800M and decreased to almost zero by 2400M. Average readings during this period reached 300 mr per hour, with maximum concentration up to 475 mr per hour. Ships experiencing this fallout were located in the general area between true bearings 110° to 155°T from ground zero, distances from 20 to 70 miles.

4. Decontamination of the ships by the ships own decontamination crews, plus natural radioactive decay, brought the radioactive intensity down rapidly. The following table shows average topside intensities in milliroentgens per hour (gamma only) of three representative ships at various times:

DATE	TIME	BAIROKO	PHILIP	GYPSY
1 MAR	0900	500	750	—
	1000	500	265	—
	1100	500	196	—
	1200	350	145	—
	1300	300	147	—
	1400	240	138	7
	1500	200	134	30
	1600	170	180	200
	1700	140	225	230
	1800	200	262	250
	1900	180	194	200
	2000	180	199	150
2 MAR	0000	160	188	130
	0400	145	156	110
	0800	134	111	80
	1200	108	78	45
	1600	36	60	40
	2000	30	47	35

DATE	TIME	BAIROKO	PHILIP	GYPSY
3 MAR	0000	27	39	35
	0400	25	41	35
	0800	22	34	26
4 MAR	0800	14	17	20
5 MAR	0800	9	8	14
6 MAR	0800	6	7	12
7 MAR	0800	4	5	10
8 MAR	0800	3	4	8

These three ships are chosen as examples because the BAIROKO and PHILIP were the most heavily contaminated in the beginning, and the GYPSY (ARSD-1) was the most heavily contaminated one week later. It is believed that contamination clung to the GYPSY longer than to other ships because of the condition of her topside, which was quite rusty due to her recent heavy employment without adequate opportunity for upkeep. Another factor tending to increase radioactive intensity on the GYPSY was her recent employment to recover contaminated chains and mooring gear from the bottom of the lagoon.

5. Three (3) barges, ten (10) LCUs and ten (10) LCMs were anchored or moored in the southeast portion of the lagoon off ENYU Island (about 20 miles from ground zero) prior to the detonation, as it was not considered practicable nor safe to take them to sea in the prevailing weather. (BELLE GROVE (LSD 2) had eighteen (18) other LCMs and one (1) AVR in her well at shot time). These craft left in the lagoon suffered no damage from blast, heat or wave action, but all were heavily contaminated by radioactive fallout to such extent that about twelve (12) hours after shot time, they had a radioactive intensity averaging several roentgens per hour. Subsequently, all were washed down with hoses from other vessels (the high pressure hoses of GYPSY proved particularly effective as GYPSY was maneuvered successively in the close vicinity of these craft), followed by a thorough decontamination by additional hosings and scrubbings by decontamination personnel who, by this time, were able to board the craft. All these measures were sufficiently effective that average radioactive intensity of these craft is now only about two (2) mr per hour (gamma only).

6. By three (3) days after the shot, all the water in BIKINI Lagoon had become slightly contaminated with radioactive material. Contamination was of the order of one microcurie per liter. Fortunately, drinking water produced by ships evaporators from lagoon water has shown no activity. The salt water systems, such as evaporators, condensers, fire mains, etc., on most ships

became gradually contaminated, and at one time it was feared this might become a major problem. However, ten (10) days after detonation the radioactive intensity of the salt water system ceased to increase, and at the present time this intensity is decreasing. The highest intensity of this kind detected was 30 millirontgens per hour (gamma only) on the exterior of an auxiliary condenser of USS CURTISS. The average intensity in the engineering space where this condenser was located was only about 2 milliroentgens per hour. As more shots were fired it is possible that higher salt water system intensities will be recorded, but at the present time it is considered that such will not prevent Task Group 7.3 from rendering the necessary support to the Scientific Task Group, although it may result in the requirement that ships remain at sea a considerable portion of the time.

7. As a result of the radioactive fallout on nearly all ships, the necessary decontamination measures following, and the radiation received by helicopter and boat pool personnel in support of the Scientific Task Group, a large proportion of the personnel of Task Group 7.3 have been exposed to radiation in varying degrees. Enclosure (3) is a nearly complete and reasonably accurate tabulation of accumulated radiological exposures of personnel of Task Group 7.3 by ships and units. (Reasonable estimates have been made in many cases since it has not been possible to provide all personnel with film badges; more information is gradually being made available as the over-worked laboratory personnel and facilities develop additional film badges.) It will be noted that the following approximate numbers and percentages of Task Group 7.3 personnel have received dosages to date in the ranges indicated:

Exposure in Roentgens	Approx. number TG 7.3 personnel with exposure	Approx. percentage of TG 7.3 personnel with exposure
0 - .999	3936	69.9
1 - 1.999	1100	19.5
2 - 2.999	325	5.8
3 - 3.999	144	2.6
4 - 4.999	83	1.5
5 - 5.999	27	0.5
6 - 6.999	7	0.12
7 - 7.8	3	0.05
Over 7.8	3	0.05

The film badges of three (3) men of an LCM crew (those listed in the "over 7.8" column in Enclosure (3)) indicated a dosage of approximately 90R. Thoroug investigation has failed to reveal how these three men could have received this much radiation; however, they have been transferred to Naval Station, Kwajalein for observation, and treatment if found necessary, by Atomic Medicine Specialists. Personnel of the PHILIP and BAIROKO have received greater exposures, in general, than other personnel. For this reason, it is planned that for all future shots of this operation, PHILIP will be employed at a location other than near the shot atoll. This will not be practicable in the case of BAIROKO, but steps will be taken to station BAIROKO, insofar as possible, in locations where the probability of receiving additional significant fallout is reduced.

8. In order to be able to continue to carry out CASTLE requirements, CTG 7.3 has requested Commander, Joint Task Force SEVEN to increase the Maximum Permissible Exposure for Operation CASTLE to 7.8 roentgens (AEC allowed exposure for 26 weeks) for (a) Helicopter pilots and plane captains, (b) Boat operating personnel of Task Group 7.3 boat pool, (c) Flight deck crew of the USS BAIROKO, and (d) Personnel attached to the USS PHILIP, approximately 490 persons in all. In the interest of efficiency and economy, this command has also recommended to Commander, Joint Task Force SEVEN that personnel not be relieved or detached from TG 7.3 units due to radiation, unless their accumulated exposure exceeds or approaches 7.8R. This command is endeavoring to employ persons with high exposure in activities where they will receive little or no additional exposure, insofar as practicable.

9. Since BRAVO was detonated on a reef, the subsequent contamination of ships by solid particles rather than water droplets, is not what ordinarily would be expected in naval atomic warfare on the high seas, although contamination by solid particles could be expected on ships in harbors or near land. Consequently, some of the following remarks on damage control measures have somewhat limited application in naval atomic warfare.

a. Especially in locations near (within about 50 miles of) ground zero, it is essential that damage control measures, including washdown, be placed in effect <u>before</u> and <u>not after</u> the fallout begins to reach the ship. This conclusion is based on BAIROKO's experience that in such locations fallout builds up very rapidly, (from 0.2 mr to 1R in less than 5 minutes).

b. Presently installed washdown systems using fine spray are only partially effective in removing relatively heavy, visible, solid particles. Heavier sprays or hoses with a large volume of water are necessary to effectively remove these particles. Further, improvements in drainage are desirable to remove the large volumes of water required.

c. Presently installed washdown systems are most effective when heading into the wind. Cross-wind headings result in much of the spray being blown from the ships structure. Zig-zagging helps in wetting all topside areas and in facilitating drainage.

d. Special measures, including more extensive washdown equipment and improved drainage, are necessary on bridge structures (especially horizontal surfaces) where critical command personnel normally are stationed. Commanding Officer BAIROKO received a relatively high dosage while conning his ship 1 March.

10. The presently prescribed methods of decontamination, both material and personnel, were found to be effective.

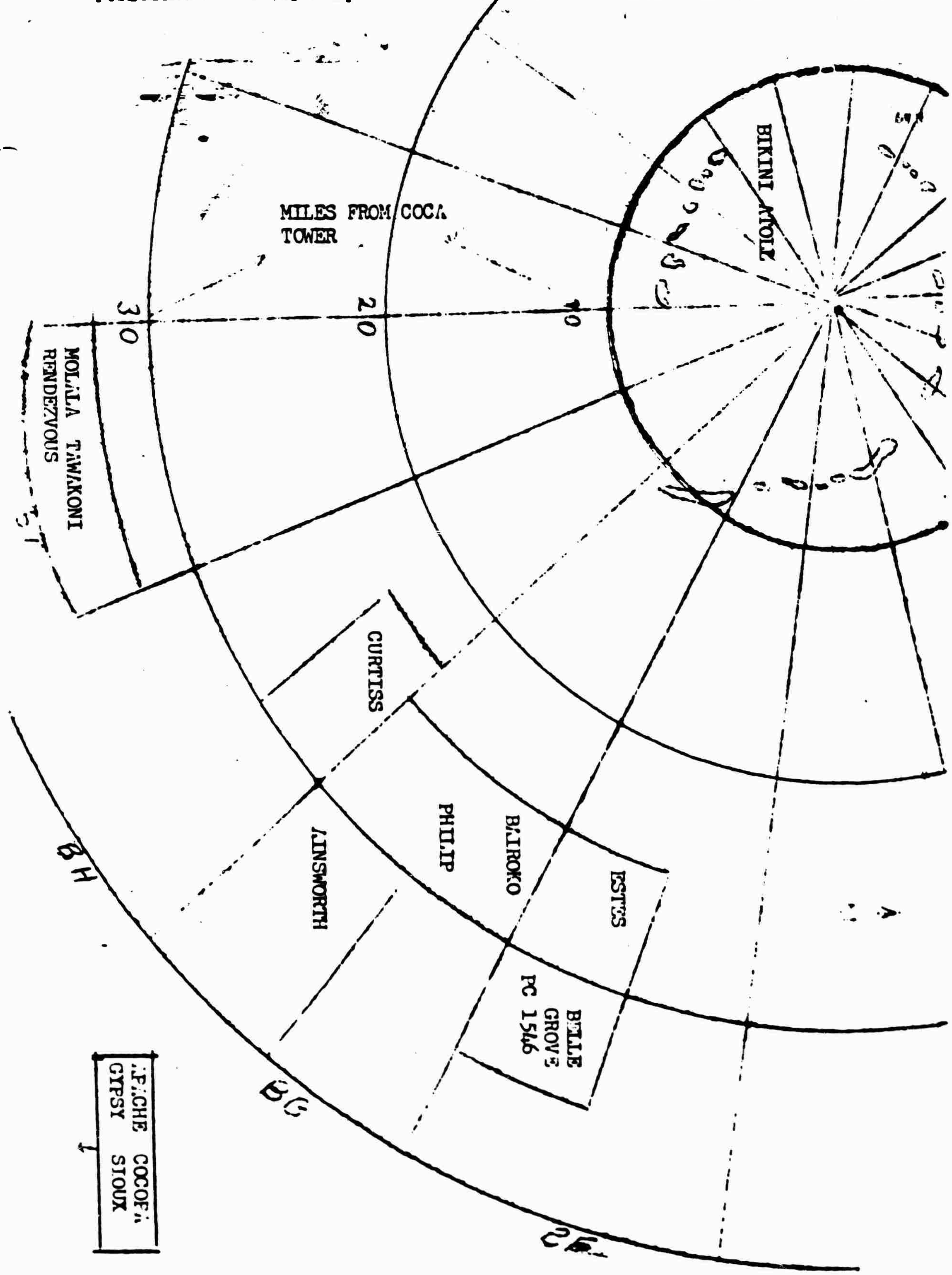
11. The excellent report from BAIROKO, enclosure (4), is considered worthy of special mention. It is believed that BAIROKO, ESTES and PHILIP were the first active ships in the Navy to be exposed to radiological fallout on a relatively heavy scale.

12. In addition to his final report to the Joint Task Force Commander on Operation CASTLE, CTG 7.3 plans to submit additional interim reports on unusual matters of naval interest, as appropriate.

H. C. BRUTON

Copies to:
- CINCPAC (3)
- CINCPACFLT (Adv Copy)
- CTG 7.1 (1)
- CTG 7.2 (1)
- CTG 7.4 (1)
- CTG 7.5 (1)
- COMCRUDESPAC (3)
- COMSERVPAC (3)
- COMAIRPAC (3)
- COMPHIBPAC (3)
- BUSHIPS (3)
- CNO (OP 36) (Adv Copy) (1)
- BUMED (3)
- NRDL (1)
- BAIROKO (1)

Positions of TG 7.3 ships from BRAVO Hour until about 0815, 1 March 1954



INCLOSURE 1

Average topside radioactive intensities (in mr per hour) of Task Group 7.3 ships at various times following BRAVO

DATE	LOCAL TIME	CURTISS	ESTES	AINSWORTH	BELLE GROVE	COCOPA	APACHE	SIOUX	PC 1546	BAIROKO	PHILIP	GYPSY
MAR.												
1	0900	8	400(e)	—	—	—	—	—	—	500	750	—
	1000	5	200(e)	—	—	—	—	—	—	500	265	—
	1100	3	150(e)	—	—	—	—	—	—	500	196	—
	1200	2	100	—	4	—	—	—	1	350	145	—
	1300	5	100	1	5	5	3	4	3	300	147	—
	1400	18	110	2	12	10	7	8	6	240	138	7
	1500	25	120	10	20	14	2	9	15	200	134	30
	1600	45	140	16	35	18	12	10	21	170	180	200
	1700	55	120	22	75	20	50	22	25	140	225	230
	1800	50	120	19	150	75	17	50	80	200	262	250
	1900	40	120	20	190	75	20	34	90	180	194	200
	2000	37	120	20	300	110	30	15	85	180	199	150
2	0000	30	120	20	80	75	30	40	80	160	188	130
	0400	25	120	20	60	70	30	30	50	145	156	110
	0800	20	80	20	60	30	25	12	40	134	111	80
	1200	15	50	20	50	20	10	10	30	108	78	45
	1600	10	30	12	50	20	10	9	20	36	60	40
	2000	10	20	10	20	18	10	7	15	30	47	35
3	0000	9	20	8	20	15	8	6	14	27	39	35
	0400	8	18	7	15	12	3	6	13	25	41	35
	0800	7	16	6	12	7	3	5	12	22	34	25
4	0800	3.2	7	5	8	5	2	4	6	14	17	20
5	0800	1.2	4	4	7	3	2	4	3	9	8	14
6	0800	1	4	3	5	2	2	4	2	6	7	12
7	0800	1	2.7	2	3	2	1	4	1	4	5	10
8	0800	1	2.1	1.5	2	1.5	1	4	1	3	4	8

All ships other than those listed in this enclosure received negligible contamination.

NOTE: (e) - estimated

TABULATION OF ACCUMULATED RADIOLOGICAL EXPOSURES OF TASK GROUP 7.3
PERSONNEL BY SHIPS AND UNITS AS OF 22 MARCH 1954

UNIT	EXPOSURE IN ROENTGENS 0.0 to 0.999	1.0 to 1.999	2.0 to 2.999	3.0 to 3.999	4.0 to 4.999	5.0 to 5.999	6.0 to 6.999	7.0 to 7.8	Over 7.8
TG 7.3 STAFF	10	47							
USS BAIROKO	448	227	40	54	64	9	1		
HMR-362		96	15	4	1				
USS CURTISS	709								
VP-29	432								
USS ESTES	145	376	115	3	5	7			
USS BELLE GROVE	166	148	22						
TG 7.3 BOAT POOL	104	96	17	8	4	1	1	3	3
USS LST 762	128								
USS LST 551	104								
USS EPPERSON	298								
USS NICHOLAS	292								
USS RENSHAW	259								
USS PHILIP	30	71	64	74	9	10	5		
USS PC 1546	53	6							
USS GYPSY	1	32	29	1					
USS MOLALA	86								
USS APACHE	83								
USS SIOUX	80								
USS TAWAKONI	76	1							
USS COCOPA	79								
USNS AINSWORTH	197								
YAG 39	47								
YAG 40	51								
TG 7.3 UNDERWATER DETECTION UNIT	22								
PROJECT [illegible] AIRCRAFT	8								
PROJECT 6.4 AIRCRAFT	8								
VC-3	20		23						
Total	3936	1100	325	144	83	27	7	3	3
Per Cent (Total)	69.9	19.5	5.8	2.6	1.5	0.5	0.12	0.05	0.05

ENCLOSURE (3)

U. S. S. BAIROKO (CVE-115)
Fleet Post Office
San Francisco, California

EOB:TELM:rd
CVE115/M3-4
Ser: 0010
11 MAR 1954

From: Commanding Officer
To: Commander Task Group 7.3

Subj: Radioactive contamination; summary of for period 1-8 March 1954

Ref: (a) Appendix IV to Annex G, CTG 7.3 OpPlan 1-53
(b) CO, USS BAIROKO (CVE-115) sec Ltr M3-4 ser 008 of 7 Mar 1954

Encl: (1) Tabulation of average intensities topside
(2) Copy of reference (b)

1. In accordance with reference (a) the following report of radioactive contamination is submitted for the period 3-8 March 1954. Reference (b) contained a report of contamination and decontamination efforts on 1 and 2 March 1954.

2. At 0830 on 3 March 1954 this ship entered BIKINI ATOLL and anchored in berth N-5. Helicopter operations were conducted throughout the day. The canvas bath tub for decontamination of aircraft was rigged on the flight deck, aft of number two elevator and all returning aircraft that had landed on the atoll were landed in the tub for monitoring and washdown with fresh water. Passengers were debarked in the tub, monitored, and processed through the forward personnel decontamination station, if necessary. No further efforts were made to decontaminate the flight deck, however, several details were busy all day cleaning out flight deck drains where high radiation reading were noted. The average intensity in these drains was between 80 and 100 milli roentgen per hour (gamma only) with one reading as high as 500 milli roentgen per hour (gamma only). Stoppages in these drains were caused, for the most part, by excess accumulation of wood splinters, rust flakes and paint chips jamming at the junction of two or more drain lines while fire hoses were being used to wash down the flight deck.

3. Decontamination work on the port and starboard gun sponsons was started after anchoring on 3 March 1954. The methods employed included hosing down with high pressure fire hoses, hosing and scrubbing with salt water and wiping down with fresh water. Number one motor whaleboat was decontaminated with a soap and water scrub down followed by a fresh water wipe down. The 40 MM gun and gun director canvas covers registered high radiation in spots where water from previous wash downs had collected in pools. By hosing and scrubbing with soapy water, the intensity of all canvas covers was reduced below 20 milli roentgen per hour (gamma only). The covers were then stowed in a void on the fantail to allow the intensity to reduce by natural decay. The average deck intensity on the starboard sponsons was reduced to

9 milli roentgen per hour (gamma only) by the end of the day. The only points of high radiation being two cocoa mat fenders which were left over the side as far removed from personnel as possible. Repeated hosings with salt water reduced their intensity from 125 to 30 milli roentgens per hour (gamma only).

4. On 4 March 1954, decontamination work on the port gun sponsons was completed. The methods used were similar to those employed on the starboard side. At the completion of the days work the average deck intensity on the port sponsons was 7 milli roentgen per hour (gamma only). The hot spots were ventilation duct screens and one cocoa mat fender, which had average readings of 30 milli roentgen per hour (gamma only). The vent screens were removed, placed on deck and scrubbed which reduced their intensity to 15 milli roentgen per hour (gamma only).

5. The average intensity on the hangar deck at 1600, 4 March 1954 was 2.7 milli roentgen per hour (gamma only). Decontamination efforts on this deck consisted mainly of swabbing up water which leaked through the roller curtain doors during hosing down operations on the weather decks. The average intensity in berthing spaces below the hangar deck was less than 2 milli roentgen per hour (gamma only) by 1600, 4 March 1954.

6. Decontamination efforts of 40 MM guns and gun directors were of minor nature. Exposed gun barrels, gun carriages, and director pedestals were scrubbed with soap and water and wiped down with fresh water. Contamination was highest in the bottom of the empty brass shutes under the elevation gear racks. The average reading was 5 milli roentgen per hour (gamma only) and the highest was 10 milli roentgen per hour (gamma only) on mount 45 which was uncovered during the period of fallout. The remainder of the work necessary on the guns and gun directors was routine maintenance to remove corrosive salt deposits.

7. While at anchor in BIKINI ATOLL the intensity reading on the salt water piping system did not exceed 2 milli roentgen per hour (gamma only), on 8 March 1954, the evaporator drain pump strainers were opened on all four evaporators. The intensity reading of the scale accumulations was found to be 5 milli roentgen per hour (gamma only). All fresh water samples from the evaporators tested by Task Group 7.1 have shown 1/5000 micro curries per milliliter or less.

8. Decontamination of the ship was considered completed at the end of the day on 4 March 1954. Decontamination of helicopters and personnel continues as required.

EMMET O'BEIRNE

Copy to:
CINCPACFLT (less Enclosure (2))
COMAIRPAC (less Enclosure (2))

TIME	POSITION LAT. N	LONG. E	AVERAGE INTENSITY IN MILLI-ROENTGEN
010700M	11°20.5'	165°47'	0.3
010800M	11°19.5'	165°41'	0.3
010900M	11°12'	165°41'	500
011000M	11°14'	165°44'	500
011100M	11°21'	165°43.5'	500
011200M	11°12'	165°40'	350
011300M	11°12.5'	165°41'	300
011400M	11°13.5'	165°39'	240
011500M	11°14'	165°41'	200
011600M	11°16'	165°32'	170
011700M	11°21.5'	165°39'	140
011800M	11°21'	165°38'	200
011900M	11°15'	165°31'	180
012000M	11°18'	165°23'	180
012400M	11°18.5'	164°22'	160
020400M	11°19.5'	163°21'	145
020800M	11°25.4'	162°31.2'	134
021200M	11°24.2'	162°22.6'	108
021600M	11°24.2'	162°22.6'	36
022000M	11°24'	162°33'	30
022400M	11°22'	163°34'	27
030400M	11°20'	164°35'	25
030800M	11°30'	165°32'	22
040800M	11°32'	165°31.5'	14
050800M	11°32'	165°31.5'	9
060800M	11°32'	165°31.5'	6
070800M	11°32'	165°31.5'	4
080800M	11°32'	165°31.5'	3

INCLOSURE 1

U. S. S. BAIROKO (CVE-115)
Fleet Post Office
San Francisco, California

EO:TELM:rd
CVE115/M3-4
Ser: 008

7 March 1954

From: Commanding Officer
To: Chief of Naval Operations
Via: (1) Commander Task Group 7.3
(2) Commander Joint Task Force SEVEN

Subj: U.S.S. BAIROKO (CVE-115); radiological contamination of

1. About 0800-M on 1 March 1954 this ship received a heavy fall-out of contaminated coral particles following the detonation of an atomic device on Bikini Atoll. At the time of the fall-out the ship was thirty-one (31) miles bearing 133°T from the shot site. The BAIROKO was in the process of launching five (5) helicopters at the time the fall-out was received and the washdown equipment was layed out in the catwalks. One helicopter was in the air but was immediately recalled and landed. The first warning of fall-out was the report of approximately one (1) roentgen per hour on the flight deck. The order to set Material Condition ABLE was given at the first indication of fall-out and all ventilation, including ventilation to the engine room spaces was shut down and remained secured for approximately two (2) hours. This prevented contamination of real consequence of any spaces below the hangar deck, the engineering spaces rising to only eight (8) milli roentgens per hour, gamma only. The wash-down equipment was turned on as soon as Condition ABLE had been set but proved to provide an insufficient volume of water to handle the heavy fall-out of contaminated coral sand deposited on the flight deck, catwalks, island structure, forecastle and fantail. Operation of the wash-down equipment was continued for approximately two (2) hours and then secured. Monitoring of the flight deck at this time gave readings as high as five (5) roentgens per hour in many of the cross deck gutters and a high of twenty-five (25) roentgens per hour was recorded in the flight deck drain on the starboard side aft. Fire hoses were then broken out and used to washdown the exposed areas for the remainder of the day. The fire hoses proved to be much superior in washing away the comparatively large particles of coral sand which had been received and it was possible to reduce the flight deck count to approximately two-hundred (200) milli roentgens per hour, gamma only, or less by 1600-M.

2. A second fall-out was received starting at about 1600-M. This fall-out was composed of very fine particles and increased the count on the flight deck and bridge to between two-hundred (200) and four-hundred (400) milli roentgens per hour, gamma only. The fire hoses were again used on the flight deck, forecastle and fantail and bridge structure until about 1845-M when the Task Unit 7.1 radiological personnel recommended sending

all personnel who could be spared below decks because of the possibility of inhaling the extremely fine particles into the lungs. No further decontamination measures were taken on 1 March 1954.

3. At 0800-M on 2 March 1954 the ship was completely monitored and the flight deck and bridge structure indicated from one-hundred (100) to two-hundred-twenty (220) milli roentgens per hour, gamma only. The hangar deck and rooms on the deck below the flight deck indicated from thirty (30) to fifty (50) milli roentgens per hour, gamma only. Decontamination efforts were commenced immediately after monitoring was completed and were carried on all day 2 March 1954. The flight deck was washed down several times using high pressure hoses, working parallel to the planking. The first wash-down resulted in an average reduction of 40-50 milli roentgens per hour, gamma only. This was followed by scrubbing with a detergent soap solution and salt water rinse, using high pressure fire hoses. The intensity on the flight deck was reduced below fifty (50) milli roentgens per hour, gamma only, except in a few scattered spaces, following repeated applications of this method. The average beta plus gamma reading on the flight deck before decontamination was one (1) r e p. The decontamination efforts utilized reduced this figure by at least 50% according to calculations of the Navy Radiological Decontamination Laboratory representatives.

4. A check on representative film badges of flight deck and other exposed personnel indicates that they received an average of from two (2) to three (3) roentgens total dose up to noon 2 March 1954. I consider that as a result of the decontamination measures taken the radiation level has been reduced to the point that the ship is entirely safe for continued occupancy by all personnel on board. I recommend that the BAIROKO continue with the operations in progress in preparation for the remainder of the tests.

5. A detailed report of the decontamination operations will be submitted at a later date.

EMMET O'BEIRNE

PRELIMINARY RESULTS NYKOPO AIRBORNE MONITORING SURVEY FLIGHTS O/A 1 MARCH 1954 (CONDUCTED BY HEALTH AND SAFETY LABORATORY, NEW YORK OPERATIONS OFFICE, AEC)

LOCATION (ATOLL, UNLESS OTHERWISE INDICATED)	LOCAL TIME (MARCH)	MAXIMUM GROUND INTENSITY (mr/hr)	LOCAL TIME (MARCH)	MAXIMUM GROUND INTENSITY (mr/hr)
ABLE				
KWAJALEIN	021800	0.6*	041200	0.5*
LAE	021210	.08	040710	.04
UJAE	021224	.10	040752	.06
WOTHO	021300	1.00	040819	1.60
BIKINI (NAMU ISLAND)			040913	96,000
AILINGINAE	021328	400.00	041011	200 to 390
RONGELAP (ISLAND)	021340	1350	(RONGELAP survey did not include RONGELAP ISLAND)	
RONGERIK	021400	1720	H+80 041410	1050
TAONGI	021525	1.4	041533	1.6
BIKAR	021628	600	041632	160.
UTIRIK	021651	240	041655	48
TAKA	021656	160	041702	44
AILUK	021716	76	041810	20
JEMO	021725	18	041820	12
LIKIEP	021740	6.0	041830	10

(NOTE: There is some doubt that intensities indicated represent the maximum for the atolls listed or that the re-survey covered the same location as the 2 March survey. Readings marked with asterisk are ground observations.)

BAKER		
NAMU	030720	.02
AILINGLAPALAP	030745	.08
NAMORIK	031423	.20
EBON	031247	.20
KILI	031224	.20
JALUIT	031206	.20
MILI	031109	.60
ARNO	031028	.60
MAJURO	031016	2.0
AUR	030945	.40
MALOELAP	030924	3.6
ERIKUB	030902	4.0
WOTJE	030850	20

LOCATION (ATOLL, UNLESS OTHERWISE INDICATED)	LOCAL TIME (MARCH)	MAXIMUM GROUND INTENSITY (mr/hr)
CHARLIE		
KUSAIE	031301	0.8
PINGELAP	031204	0.6
MOKIL	031130	0.6
PONAPE	030945	0.8
UJELANG	030820	0.8

MAXIMUM GROUND READINGS OTHER NYKOPO FLIGHTS (IN MR/HR)

Flight EASY (6 March) 0.0
Flight GEORGE (6 March) 0.2
Flight ITEM (5 March) 0.08
FLIGHT KING (Gilbert Islands) (6 March) 0.08

DISCUSSION OF OFF-SITE FALLOUT

Fallout off-site followed the pattern immediately established at and adjacent to the proving ground where the cloud in general moved east north easterly with prevailing winds. Task force ships southeast of NAN received the first fallout, being on the southern edge of the main strip of contamination. Fallout on the ships ranged from intensities of 500 milliroentgens per hour on the BAIROKO which was closest to the center of the fallout path to a few milliroentgens per hour on vessels farther south.

Fallout began at RONGERIK Atoll at 1348 hours, 1 March as shown by a self-recording radiation detection station placed there by the HASL NYKOPO AEC and operated by personnel of the Air Weather Station. This instrument went off scale at 100 mr per hour at 1418 hrs 1 March. Based upon query from air weather personnel a monitor was dispatched with the supply PBM on the morning of 2 March. A ground reading of 2000 mr/hr was obtained at 1115 by the monitor who evacuated 8 of the personnel on his own initiation and recommended evacuation of the remainder as soon as possible based upon the high radiation levels. This was concurred in and the remaining 20 were evacuated by PBM at 1645, 2 March. Calculations estimating the dose received indicated that personnel evacuated at 1115 would have received 85R and the remainder 95R. This was in fair agreement with readings of film badges on personnel. Maximum film badge reading was 98r representing 3 men, 52r for 1, 44r for 1, 40r for 9. Average dose for all personnel, 54 roentgens.

Inasmuch as the data from RONGERIK is the only data showing exact time the fallout occurred at any location east of the proving ground and adjacent to populated islands affected by substantial radiation, its importance is such that calculation of dosages received by native populations are based upon it for time of fallout in those locations.

Survey of RONGELAP was made by Pattern ABLE of Security Patrol Squadron (Patron 29) with NYKOPO Scintameters aboard on 2 March which found an estimated reading of 6750 mr/hr. (Later calibration for aerial survey equipment revised this to 1350). Based on this and its proximity to RONGERIK it was decided that it would be necessary to evacuate the atoll. Consequently, the PHILIP, DDE 498, was dispatched to reach RONGELAP on the morning of 3 March. In the meantime a PBM was sent to ground survey the atoll and at 1830 hours, 2 March, their ground survey showed a reading of 1400 milliroentgens per hour. Calculation of dosage to 3 March indicated about 110 roentgens so the order to evacuate was given. The destroyer PHILIP evacuated the natives by 0935 to 1025, 3 March. Calculation of the total dose indicated that 130 roentgens were received. A total of 65 natives were removed, 16 natives (the old and sickest) by PBM and 49 by DDE.

Inasmuch as some natives of RONGELAP were reported to be on AILINGINAE, the atoll was surveyed, 17 natives located, and an intensity of 445 mr/hr was found. Evacuation was complete by 1800, 3 March. The dose computed for this group was 80r.

Aerial survey of UTIRIK by ABLE Pattern indicated 620 mr/hr at 1651 hrs, 2 March (later re-calibrated to 240 mr/hr). On 3 March 1345 ground survey indicated 160 mr/hr. The decision to evacuate was based upon the fact that the estimated dose at time of earliest evacuation would be 13r. Evacuation was complete by 1245 hrs, 4 March. Estimate of dose to actual evacuation time was 17r. 154 natives were evacuated.

The only other populated atoll which received fallout of any consequence at all was AILUK. ABLE Pattern indicated 95 mr per hour at 1845 hrs 2 March. Based upon the best estimate of fallout time it was calculated that a dose to infinite time would reach approximately 20 roentgens. Balancing the effort required to move the 400 inhabitants against the fact that such a dose would not be a medical problem, and corresponded to the task force standard of 20r for sampling aircraft crews, it was decided not to evacuate AILUK.

Indications from aerial surveys indicated substantial fallout occurred on the unpopulated islands of BIKAR and TAKA.

Very minor fallout occurred in a southwesterly and westerly direction on ENIWETOK and UJELANG Atolls but levels did not exceed 10 mr per hour at ENIWETOK nor 3 mr per hour at UJELANG. This was apparently very fine particulate matter carried by the low trade wind component.

A detailed plan was made to make ground surveys of all islands which had fallout in excess of 10 mr per hour at estimated fallout time to provide information as to decay rate and verification of estimation of doses.

PATTERN OF FALL-OUT FOLLOWING BRAVO EVENT
(Combined Analyses - Immediate and One Week after BRAVO)

1. General. The pattern of ultimate fall-out of radioactive particles has been established utilizing in the cases of the most critical area (i.e. bearing about 050° True, clockwise to 120° True from Ground Zero) the following:

a. Aerial survey by P2V employing HASL NYKOPO AEC survey equipment, with readings in mr/hr extrapolated to ground level.

b. Known ground readings taken at some atolls (early and later) used with their time and intensity (actual observations) to get a feeling for the overall situation.

c. Resultant wind pattern to establish best wind for period from H minus 1 hour (USS CURTISS Observation - BIKINI) to H plus 8 hours (RONGERIK sounding) together with the H minus 3½ hours (RONGERIK 0300M) to piece together the wind pattern above the tropopause.

d. Since the RONGERIK NYKOPO AEC survey meter trace established initial time of arrival of fall-out, this time was used in coordination with resultant wind at the cloud level which passed over RONGERIK. This level was the 25,000 feet vector. Its average speed from Ground Zero calculated from resultant wind plot was 10.4 miles/hr. At first, there was considerable difficulty in making fall-out arrive from the stem of the atomic cloud (0-55,000 feet-tropopause) at RONGERIK in 8 hours. The 10.4 miles/hr above would make cloud arrive at RONGERIK at about H plus 12 hours. However, by the method of plotting the entire cloud height (which is believed to be about 100,000 feet) for which there were available winds to 95,000 feet, and with the assumptions listed below in constructing shadows (fall-out) of stem and mushroom, there are obtained 2 areas - elliptical in shape, generally east of Ground Zero and superimposed on each other (Appendix I). The suggested fall-out area for the stem is oriented about 070° True from point SE of Ground Zero, distance 35 miles and with a 200-mile major axis, 100-mile minor axis with a series of extremely hot elliptical envelopes emaanating from Ground Zero out to about 110 miles. Superimposed on this area is the suggested mushroom fall-out pattern which is an ellipse oriented 080° True, 40 miles from Ground Zero, major axis at least 180 miles, minor axis 45-90 miles. It is assumed that the cloud diameter in the mushroom for the period in question was at least 70-100 miles. This shows therefore, that the early fall-out at RONGERIK could come easily from the mushroom - large particles by H plus 8 hours, and since the superimposed fall-outs from stem and mushroom cross the northern half of RONGELAP Atoll, one would expect these islands to be exceedingly high with their radiation levels. This might be likened to scavenging of the hot stem material by large particles from the tropopause and above. However, the major hot fall-out element must come from the stem debris.

INCLOSURE 11

The assumptions used in the rough construction of the ellipse for the whole cloud-are: (See USAF ARDC Report C3-36417, Nov 1953, Radioactive Fall-out From Atomic Bombs.)

(1) If wind shear is less than 10° for the levels in question, minor axis is 1/8 to 1/4 of the major axis (which is the entire vector for levels looked at). (This is case of 0-5,000 feet winds and 5-20,000 feet winds.)

(2) If wind shear is more than 10° but less than 120°, minor axis is ½ of major axis. This is case for 20,000 feet winds to tropopause, and somewhat less for 65,000 to 95,000 feet winds.

(3) If shear at levels making up vector under study is more than 120° draw circle with diameter = to entire resultant vector.

CONCLUSIONS:

1. From overall fall-out picture, it is concluded that fall-out may have reached RONGELAP Island and AILINGINAE later than the pessimistic time of H plus 5 and H plus 4 hours, respectively.

2. From initial land survey reports on RONGELAP Atoll with levels at ERIPPU Island (NE part of Atoll) still at 2.8 to 3.5 r/hr on B plus 7 days, the picture for heaviest fall-out patterns north of this area is established. The relatively light fall-out at UTIRIK (ESE of the hot area), higher levels of intensity at BIKAR (East and downwind of the hot area, i.e. 600 mr/hr at H plus 33 hours almost in downwind line with the superimposed ellipses or hot areas but definitely beyond the hot shadow), confirm the belief in the assumed area of hot fall-out pattern above. WOTHO (SSE of the area and from Ground Zero) received practically nothing because resultant vector wind speed from the stem and, perhaps some of the mushroom fringe, was so low in velocity through the SE to South from Ground Zero. ENIWETOK received at about H plus 11 hours a build up to about 10 mr/hr for a period of about five hours.

3. This type of analysis gives a feeling only for pattern of fall-out because it does not tell exactly when the fall-out arrives. However, it is apparent that the 200-300 plus roentgens lifetime dosage line passed on or close to AILINGINAE, RONGELAP Island and RONGERIK which are at 80-100 miles in cases of AILINGINAE and RONGELAP and 130 miles to RONGERIK from Ground Zero. The 1,000 plus roentgens lifetime dosage lines are exceeded as one goes north from RONGELAP Island to northern islands of that atoll. This analysis is based on : (1) logical use of wind patterns existing during shot time to fall-out, (2) multiple shot (tower or gound) fall-out pattern data from Nevada Proving Grounds over last 3 years, and (3) experience and data from IVY-MIKE (limited cross-wind and upwind) and CASTLE-BRAVO itself.

4. RONGERIK radiation intensity levels are known at onset and evacuation time; calculated roentgen dosage agrees with actual observations from film badges at this site.

5. The heaviest fall-out pattern was expected to pass north of NAN and east northeast from Ground Zero.

6. The levels of radiation intensity at the distance of RONGELAP and RONGERIK were much higher than expected, and sooner than expected since necessary information in this range of yield for surface shots today is the result of scaling up from much lesser yields, interpretation of upper wind field patterns, coupled with forecast changes and experience of individuals with such limited data as IVY-MIKE, GREENHOUSE-DOG, EASY, GEORGE and ITEM.

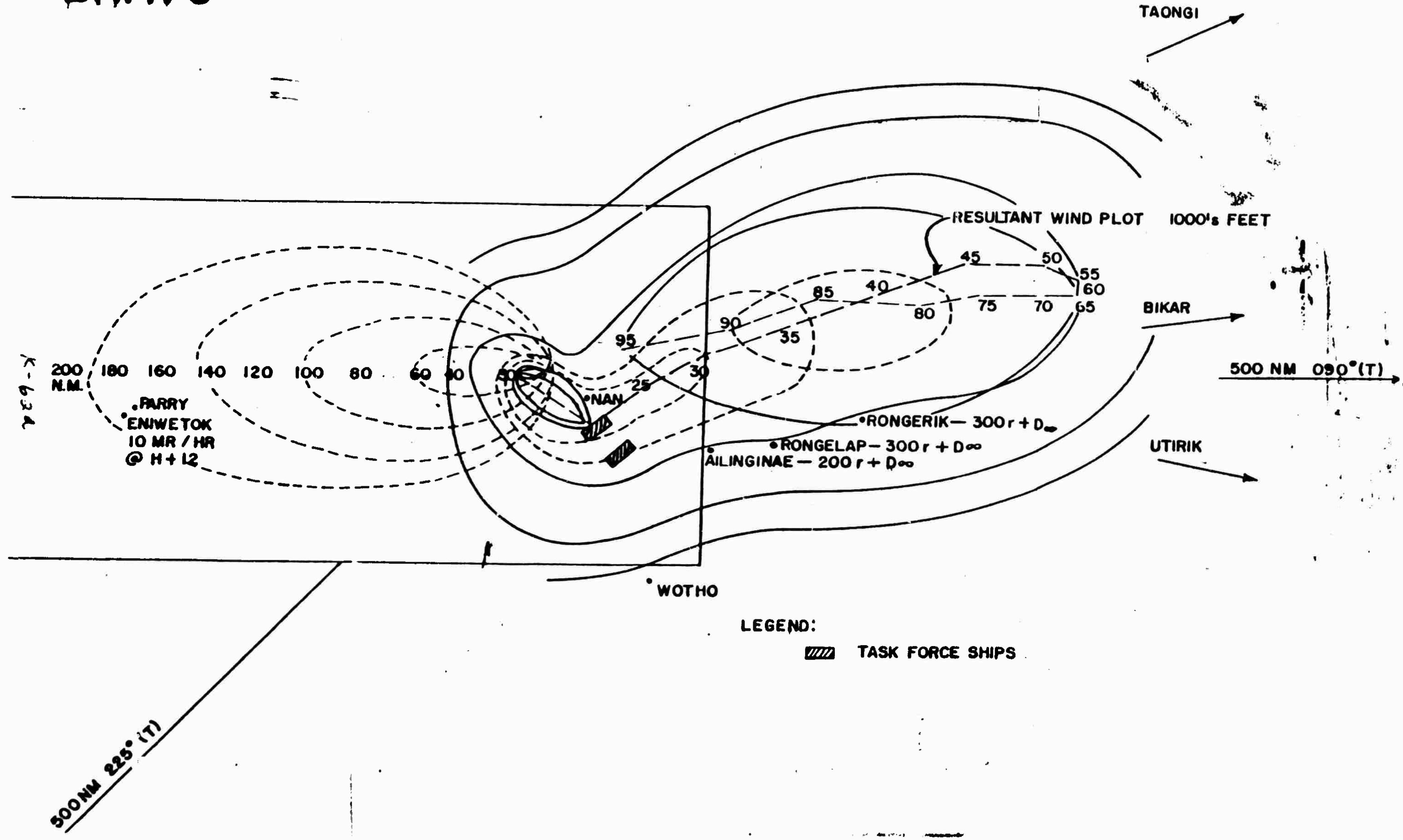
7. BRAVO cloud pictures (Project 9.1, taken from an airplane) indicate large quantities of visible particulate matter falling through the great heights (i.e. up to at least 100,000 feet) is a must for shot time, since the fall-out problem for surface or near surface shots of large yields can be a definite function of the mushroom as well as the very hot stem of the cloud.

Appendix:

I - Plot of General Fall-out Pattern
II - Tabulation of Time of Arrival Data

R. H. MAYNARD
CAPT., USN

BRAVO



LEGEND:

TASK FORCE SHIPS

BRAVO

PLACE	TRUE BEARING	DISTANCE NAUT. MI.	TIME FALLOUT ARRIVED	INTENSITY MR/HR	DOSE ROENTGENS	INTENSITY MR/HR	TIME HRS	INTENSITY MR/HR	TIME HRS/DAS	AVERAGE RESULTANT WIND SPE TO TROPO
LAE	160	174	+39hrs			.08				3.2
UJAE	170	168	+37			0.1				3.2
WOTHO	154	100	+13.2	2.3	.17	1.0				3.8
AILINGINAE	115	79	3.6	12,000	220	445	+58	400	+29.7	8.1
RONGELAP	109	100	5.6	9,800	350	*1400	+36	1350	30.9	8.9
ENIAETOK	105	98.5	5.4	46,800	4,200	*3000	+53.2			8.9
RONGERIK	098	133	+8	9,000	350	2000	+28.5			10.4
TAONGI	052	280				1.4	32.6	Fringe effect only		
BIKAR	084	285	16.3	1,400	120	600	33.0			14.4
UTIRIK	096	270	21.6	450	48	160	+55	53/10	+6.3 days	10.2
TAKA	097	261	20.3	290		160	+34			10.4
MEJIT	104	340	30.2							9.6
AILUK	107	291	27.1	110	13	76	34.8			8.9
JEMO	110	268	24.8			18	34.7			8.8
LIKIEP	115	262				6	34.9			8.1
NAMU	142	265				.016	48.5			4.2
AILINGLAPLAP	142	338				.08	48.9			4.8
ARNO	127	464				0.6	51.6			5.3
MAJURO	128	441				2.0	51.4			5.5
AUR	122	400				.36	50.9			5.9
MALOELAP	117	387	42.3			3.6	50.6			7.1
ERIKUB	119	321	40.0			4.0	50.2			6.8
WOTJE	114	321	39.0			20.0	50.0			6.0
KUSAIE	200	225				.5	54.4			
PONAPE	235	503								
UJELANG	245	235				2.0	49.5			
PINGELAP	220	426								

* Reading on ground.

12 April 1954

MEDICAL ASPECTS OF FALL-OUT FROM BRAVO

1. Medical evaluation of personnel exposed to the radiation from fall-out in the case of BRAVO depends to a great extent upon the accuracy with which dosage can be computed. Based on extrapolation of fall-out time from RONGERIK data where the fall-out time was precisely determined by automatic recording instruments, it seems plausible to conclude after making allowance for factors giving maximum values of time and intensity, that personnel were not exposed to dosages much higher than calculated. This is particularly true inasmuch as RONGERIK calculations were in good agreement with observed film badge data on personnel there.

2. The association of symptoms with a given dosage may lead to erroneous conclusions since such tabular relationships have been devised only for whole body penetrating radiation given over a period of a few minutes. It is now generally believed that the symptoms in those tabulations will appear with a smaller dose than indicated. These personnel may develop signs or symptoms out of proportion to what would have previously been expected but could be somewhat tempered by the relatively slow dose rate characteristic of fall-out.

3. With respect to natives, due to the language difficulty, it was extremely doubtful that information obtained by questioning would be reliable.

4. We may draw certain conclusions, however, which seem to be sound concerning immediate prognosis based upon the doses believed to have been received.

5. Considering the personnel involved in exposure to radiation they can be grouped according to location:

a. RONGERIK -

Twenty-eight Americans were exposed showing film badge readings ranging from 40 to 90 roentgens during a period of 28.5 to 35 hours. They were evacuated to KWAJALEIN. It was not expected that any of these men would develop any subjective symptoms. One admitted to feeling badly until reassured, after which he admitted that his feeling was probably psychological. First blood counts taken on D plus 1 showed a normal distribution. Generalized loss of hair which usually occurs after 10 days with sufficient dosage was not expected and has not occurred to date (12 April). Levels of personnel contamination were not exceedingly high and inasmuch as decontamination was performed on D plus 1, beta burns are unlikely.

INCLOSURE 12

b. RONGELAP -

Sixty-five natives were evacuated to KWAJALEIN and may have received doses as high as 130 roentgens in a period of 51 hours. In this case, the level of radiation is about the level which might cause some symptoms such as nausea, vomiting, fatigability and lose of hair for acute doses. Allowing for the reduced effect from low dose rate it may happen that symptoms as above will occur in individuals who were already ill or in generally poor physical condition. Readings of skin and hair contamination were such that for this exposure time spotty distribution of beta burns could occur within several days. If this occurs, ulcerations might develop which may require several months to heal.

c. AILINGINAE -

Seventeen natives on this island were exposed to approximately 80 roentgens in 58 hours. They were evacuated to KWAJALEIN. It was not expected that any subjective systemic symptoms would develop. However, personal contamination of this duration could conceivably cause beta burns in a spotty distribution with ulcertaion as described above.

d. UTIRIK -

154 natives were evacuated to KWAJALEIN after receiving a dose of 17 roentgens in 78 hours. No subjective systemic symptoms or changes in blood count were expected. Beta burns are unlikely but are possible statistically.

e. AILUK with 401 natives was not evacuated and the total dose for a life time will be less than 20 roentgens. No medical problem from radiation should occur in the population.

f. Some other islands received fall-out exposing inhabitants to insignificant quantities of radiation.

g. Task Force personnel at or in the vicinity of BIKINI Atoll -

Personnel in the concrete bunker on NAN island were evacuated to ships afloat receiving in general comparable dosage to those aboard ships all the time. Based on readings taken aboard the ships it was estimated that none of the ship's personnel would receive more than 10 roentgens whole body radiation. This dose would not cause any general symptoms of radiation sickness, however, decontamination personnel might have skin contact with concentrated radioactive deposits and possibly sustain mild beta burns.

6. All native evacuees were held at KWAJALEIN for observation and treatment should the need arise. The station medical complement took complete blood counts, made physical examinations and took histories. Captain H. H. Haight, (MC), USN, a radiological medical officer was sent to KWAJALEIN as consultant on radiation effects to the station surgeon. Daily observation was instituted in anticipation of the arrival of a medical group from the U.S. who were to investigate the patients.

7. The medical group arrived at KWAJALEIN on 8 March. It consisted of military and civilian medical officers and technicians from the Naval Medical Research Institute, the Armed Forces Special Weapons Project and the U. S. Naval Radiological Defense Laboratory and was established as Project 4.1, TU 13 of Task Group 7.1 with Commander E. P. Cronkite, MC, USN, as Project Officer. Drs. G. V. Leroy and C. L Dunham represented the Division of Biology and Medicine, AEC, and were to act as advisors to Project 4.1. A systematic organization was set up with a view toward running a sick call, performing blood studies, taking histories, making physical examinations and documenting the cases by means of records and photography. Buildings were furnished for these purposes by COMNAVSTAKWAJ and his station surgeon, Commander W. J. Hall, worked closely with the group. The establishment of the investigating group of Project 4.1 was essential and desirable from several standpoints. All the medical personnel were experienced in the field of atomic medicine having been participants in previous testing using biological material as well as having had full time research projects along this line during interim periods. This allows for proper evaluation of human effects toward correlation with the data on animals from which a great deal of our ideas on human effects have been extrapolated. Further, they constitute an augmentation medical group for treatment if necessary in conjunction with station medical facilities. An additional advantage was that almost all of the personnel had worked together as a unit on previous occasions.

8. None of the natives nor the RONGERIK Americans had preliminary or early systemic symptoms consistent with radiation sickness from large dosage of external whole body irradiation. A reported case of vomiting and a few cases of loss of appetite were not significant considering the sudden change in environment and diet to which they were subjected. To relieve the load on the station medical facilities, not knowing of the early arrival of the medical group, the twenty-eight Americans were returned to ENIWETOK to remain as out patients under the supervision of the Surgeon, Task Group 7.2. Blood counts were taken at approximately three day intervals. They remained asymptomatic although there began a depression of the white blood cells of mild degree. They were returned to KWAJALEIN on 17 March. During the early days of March all patients remained free of systemic symptoms attributable to irradiation but there was a definite decrease in the white cell count, more marked in the RONGELAP group. The blood pictures of the AILINGINAE natives and the RONGERIK Americans were quite similar which was reasonable considering they were exposed to the same order of magnitude of radiation. The UTIRIK group showed nothing particular from a medical standpoint and were considered as a virtual normal native population for comparison purposes

pending time for obtaining base line data from non irradiated natives.

By the thirteenth and fourteenth day a tendency to epilate had become evident in the RONGELAP natives involving mostly children but within a few days it had appeared in adults. The epilation was both patchy and diffuse, confined mostly to the head and particularly in children the scalp assumed a spotty appearance due to depigmentation of the skin.

At about the same time that epilation appeared in the RONGELAP group, small skin lesions became noticeable on the folds of the neck, the forehead, shoulders, and arms. They appeared to be superficial and at first were hyperpigmented. As time went on, the lesions, which became blister-like, began to peel leaving a whitish depigmented area in the center. The skin manifestations continued to appear throughout the month of March, all going through the same cycle and involving most of the natives. The most severe cases occurred on the feet with one exception - one man developed a deep ulcer behind one ear. By this time (12 April) all of the skin lesions except the ear have virtually healed and it appears that repigmentation is taking place.

Similar findings but in a lower percentage and at a later date occurred in the AILINGINAE group. One American developed what appeared to be superficial radiation lesions on the back. They were hyperpigmented and behaved as the others.

Throughout, there have been no demonstrative systemic symptoms other than an epidemic of colds in the RONGELAP group. A few cases of secondary infection from skin lesions and some unexplained high fever in children responded well to penicillin with no sensitization reaction.

The white blood counts reached a minimum during the latter part of March with a late depression in blood platelets becoming apparent. The level of the mean counts being well below normal mean counts. Lowest counts were about 30,000 compared to a normal mean of over 300,000 for the natives. There is a definite upswing in the entire blood picture of both the natives and Americans at the present time (12 April).

On about 20 March, several cases of radiation burns were reported aboard both the USS BAIROKO and the USS PHILIP. Examination showed that in almost all cases there were discrete areas around the belt line which corresponded well to some lesions seen on the natives. History indicated that these lesions developed sometime between 3 March and 15 March. All were in the process of healing with desquamation and mild depigmentation and were quite superficial. The whole body dose was less than 10R and there were no other symptoms.

Three M-boat operators from TG 7.1 presented film badges reading from 85 to 95R and were sent to KWAJALEIN to be observed by the medical team on 16 March. Since that time they have had no symptoms, no skin findings nor blood changes. It is likely some discrepancy in badging or wearing of badges must have taken place as careful examination of the badges by densitometer revealed nothing unusual in the radiation to which they were subjected.

It was decided at the outset to manage all cases in a conservative manner, treating symptoms as they arose, avoiding experimentation with treatment but being ready at any time to perform transfusions either of whole blood or platelets if indicated. Sick call was managed daily where complaints were treated as though radiation had not been present. Skin lesions were kept clean by surgical soap with excellent results leading to a minimum of secondary infection and remarkably prompt healing. It is felt that this conservative regimen gave optimum results and that all patients are recovering satisfactorily.

Detailed reports will be rendered by Project 4.1 on all cases. Detailed statistical analyses will be required to properly evaluate the data derived. Urine samples which have been analyzed in the U.S. will be combined with this study. A detailed study of characteristics of the fallout samples, shielding properties of the measuring instruments, and weather analysis will be necessary before a more exact dose of external whole body radiation can be established. The study of all aspects should lead to a much clearer concept of dose versus effect. The picture of external gamma radiation with a broad spectral band, combined with external beta radiation, and internal hazard makes a very complicated problem in the final reports.

As a corollary to immediate treatment of the personnel exposed to the radiation, evaluation of the hazard remaining upon rehabilitation must be investigated. To that end soil and water samples, animals, plants and other comestibles are being investigated with a view of determing if and when the natives may be returned to their home atolls.

All personnel who have been involved in large dose exposures and those whose dose was small but who may have to reside in an active area should be observed over a long period of time. The first year following the tests, re-examination should be at quarterly intervals. This has been discussed with the Director, Division of Biology and Medicine, AEC, who advises that it is the intention of his organization to maintain a periodic observation system.

In summary, natives from adjacent atolls and Americans from the Task Force were exposed to radiation in doses from a few roentgens to approximately 150 roentgens. Some of the more heavily irradiated may be considered to have been borderline from a standpoint of seriousness. All should recover from the effects of the exposure.

CLINTON S. MAUPIN
Colonel, Medical Corps
Staff Surgeon

10 March 1954

MEMORANDUM FOR RECORD

SUBJECT: Protection of Transient Shipping During Operation CASTLE

1. In order to provide protection for transient shipping in the region immediately outside the ENIWETOK/BIKINI Danger Area during Operation CASTLE planning factors were established and a plan of action placed in effect as follows:

a. Planning factors:

(1) CASTLE clouds more than 24 hours old should not be hazardous.

(2) 24 hour travel of a CASTLE cloud should be approximately 500 nautical miles.

b. Plan:

(1) The Commander in Chief, Pacific Fleet was requested to make advance diversions of shipping outside a sector area from southwest clockwise through north to east to 500 nautical miles from ground zero from H to H plus 24 hours.

(2) P2V aircraft were planned to sweep the significant forecast sector of cloud travel, using visual and search radar methods of sightings out to 800 nautical miles on D-2 days, out to 600 nautical miles on D-1 day and, if necessary, in front of the cloud on D day. P2V aircraft crews were directed to effect diversion on all ships sighted in the sector area on D-1 and D Day.

(3) WB-29 aircraft on routine weather reconnaissance missions were directed to report all sightings of surface shipping encountered. All sightings were to be relayed to the Radar center (CIC USS BAIROKO) in the TG 7.3 fleet.

(4) P2V aircraft and destroyer security sweeps were directed for the ENIWETOK/BIKINI Danger Area. Information from these sweeps was channeled to the Radar center (CIC USS BAIROKO).

(5) Information from all the above sources was channeled into the task force headquarters for evaluation and consideration at the Weather/Radsafe Command Briefings.

INCLOSURE 13

2. The results of the above efforts for BRAVO were as follows:

a. All known transient shipping was diverted outside the hazardous fall-out area. The Patapsco (AOG-1) was sailed from ENIWETOK to be out of the hazardous area by shot time. The Trust Territory ship M/V Roque was operating outside the designated sector (from KWAJALEIN to UTIRIK), arriving at UTIRIK on the morning of 2 March 1954 and departing UTIRIK on 3 March 1954. The Roque was subsequently located and monitored at MAJURO and found to have insignificant levels of radiation. The Merapi was enroute from Honolulu to ENIWETOK but well outside the designated sector area at shot time. The Merapi was monitored upon arrival at ENIWETOK and found not contaminated.

b. Based on the forecast significant cloud travel (forecast made on the night of B-3 days) the P2V sweep for B-2 days was directed along true bearing 300 degrees from ground zero. No ships were sighted on this sweep. Based on the B-2 day shot time forecast, the P2V sweep for B-1 day was directed along true bearing 330 degrees to a distance of 375 nautical miles. The reduction in distance was based on forecast reduction in resultant wind speeds. This sweep contacted the USS General Patrick at 17-31N, 162-03E on course 266 degrees, speed 16 knots, at 1204M, 28 February 1954. As she would clear the designated sector by shot time, she was not diverted by the patrol aircraft. Based on a re-forecast (made on B-1 day) of the significant cloud movement for B day, it was decided to search in advance of the cloud along bearing 65 degrees true from ground zero out to 600 nautical miles. Two P2Vs were used. The first of these became contaminated early in its mission and was forced to return to base. The second was directed to pick up the search in the approximate location of the previous abort and carry it out to the 600 miles. The only contact reported by these aircraft was the Patapsco (AOG-1) sighted at 12-31N, 170-48E, at 1935M, 1 March 1954, course 30 degrees, speed 10 knots. The Patapsco was turned to an easterly heading at 2030M, 1 March 1954. The Commander in Chief, Pacific Fleet was advised later to have the Patapsco monitored upon arrival at Honolulu in the event a check enroute could not be accomplished.

c. Between 26 February and 1 March 1954, WB-29 aircraft performed weather and cloud tracking missions in all four quadrants from ground zero. No surface shipping was sighted on these missions, three of which were flown to the east northeast of ground zero, one on 27 February and two on 1 March 1954.

d. The P2V and destroyer search of the ENIWETOK/BIKINI Danger Area made no contacts. As a matter of interest, a destroyer security sweep on 17 February 1954 encountered one Japanese fishing vessel, the Miyagikenajinoiokonpiramaru, 26 nautical miles on true bearing of 40 degrees from ENIWETOK Island. This ship was escorted toward the northern edge of the Danger Area and left on course 315 degrees, 9 knots with the recommendation that air patrol observe its subsequent movements. No further contacts with this ship were reported.

e. As a summary, the CIC BAIROKO was contacted periodically pre-shot and reported no transient shipping in the area.

TAB "L"

ROMEO EVENT

TAB "L"

ROMEO

The first attempt to fire ROMEO was 13 March. R-5 day advisories were dispatched to the external agencies (Chairman, AEC, C/S Army and CINCPACFLT) scheduling ROMEO for 130640M. A search sector was flown on 11 March to 800 NM to identify shipping in the area. Negative results were obtained. A 500 NM sector search was flown on 12 March to identify shipping, to determine course and speed, and to attempt to turn all shipping outside a 500 NM sector 225° to 90° True (the forecast significant fall-out zone) for H to H plus 24 hours. No contacts were made by the search aircraft.

The task force headquarters and task group staffs deployed to Bikini on the 11th and 12th of March. By noon on 12 March the synoptic weather situation was such that, although a complete series of pre-shot advisories were issued to external and internal agencies, statements were included that it was not anticipated ROMEO would be fired on schedule unless the winds and weather improved. It appeared that deep easterlies were dominating the wind flow pattern, a fact which materialized by the evening of 12 March. At 2100M on 12 March, all advisory addressees were notified that, due to the adverse effect of high clouds on the essential sampling effort and an unfavorable fall-out pattern, ROMEO was re-scheduled for 150640M, but that if weather permitted, the capability was being maintained to advance this time 24 hours to 140640M.

Deep easterlies prevailed through 18 March, during which time an 18-hour capability of firing ROMEO was maintained. By noon on the 19th, the forecast for shot time the following day was for east-southeast winds from surface to 25,000 feet, southwest to 55,000 feet and easterlies above 55,000. A series of Command Briefings and pre-shot advisories were again completed. However, by 2100M on the 19th, it was apparent that the southwesterlies were not materializing, and the shot was postponed for 24 hours.

During the interval between the two attempts to shoot, it was apparent that the IVY search plan for the protection of transient shipping was not flexible enough to cope with the large shifts in the long range forecast fall-out pattern which could occur over a period of two days before a shot. Advance contacts were required to detect and turn shipping out of the large areas which could reasonably be expected to lie in the fall-out zone. As the pre-shot schedule progressed, changes in wind forecasts reflected themselves in corresponding shifts in the forecast significant fall-out area. As a consequence, not only was much search effort usually wasted, but far more important, the time remaining in which to divert a slow-moving surface vessel became inadequate. Further, although advance arrangements had been made with CINCPACFLT to divert shipping outside a 500 NM sector area centered on GZ from southwest through north to east from H to H plus 24 hours, this action applied only to U.S. shipping plus such other vessels as occasionally came within the knowledge and coordination of CINCPACFLT commands. As a consequence, the search plan was revised to specify as an enlarged Danger Area, a 450 NM sector centered on 12N, 164E with limiting true bearings of 240° clockwise through 95°. Notices to all nationalities were issued to this effect. In addition, for search purposes, an internal area bounded by 10-15N, 16-40N, 160-10E and 170-20E was designated Area GREEN. This area (less the included former Eniwetok-Bikini Danger Area) was within the search capabilities of three radar equipped aircraft operating over a period of approximately ten hours; search of the former Eniwetok-Bikini Danger Area was left unchanged. This improved the situation to such an extent that the total exclusive character of the enlarged Danger Area could be relied upon to maintain a clear sector, whereas the search of Area GREEN was such that it became essentially a check of compliance with the Danger Area notice and could be initiated late enough in the pre-shot schedule of events to avoid most of the delays if the forecast winds did not materialize.

On 19 March, due to the transient shipping incidents arising from BRAVO, CINCPACFLT issued instructions to all military agencies operating in the Pacific to the effect that, until further notice, all Pacific Fleet vessels except those assigned to JTF SEVEN, entering a circular area within 450 NM from a point 12N, 164E would ensure the wearing of casualty film badges and/or phosphor glass dosimeters by 5% of the personnel aboard until the vessel departed from the area. The directive further contained a recommendation that the instructions apply to MSTS ships as practicable.

At about the same time, an interchange of advisory dispatches and recommendations took place between the Task Force and CINCPACFLT culminating in a re-statement of Task Force policy relative to closure of airways. The pre-BRAVO Task Force Radsafe plan contemplated closure of airways only when actually required and maintenance of the closed status only until the danger subsequent to each shot had passed. Arrangements had been made by CINCPACFLT with those in charge of military airways and the Regional Administrator of the CAA to effect temporary and prompt closure of air routes when the need arose. No change was made in the basic plan as stated above.

Also, during the interval following BRAVO, a change was made in the method of computing the Air RADEX. Prior to this time (including Operation IVY), the classical method of computation as outlined in Air Weather Service Manual 105-33 had been used. A basic assumption of this method is that the source of radiation consists essentially of a point-source in all directions except the vertical. Surface RADEX computations prior to BRAVO had taken the point-source factor into account (using a circular source of 15 NM radius, later revised upward based on BRAVO to about 25 NM); a similar modification in the Air RADEX computation was devised and applied to all future forecasts, with completely satisfactory results.

Further postponements and re-scheduling of the ROMEO shot resulted in progressive daily weather/radsafe checks. At noon on 21 March, the synoptic weather situation was again such as to place some hope on the 22nd being a shot day. A series of Command Briefings and pre-shot advesories was again completed on 21 March and continued until about 1900M, at which time it became apparent the hoped-for winds were not materializing. The shot was postponed indefinitely, and the Task Force placed on an 18-hour capability. In accordance with radsafe surveys and lagoon water sampling, and in the interest of morale of the Bikini personnel, swimming was permitted (since 14 March) at the southwestern beaches.

On all the attempts to shoot, advance preparations included the fleet going to sea in the evening of minus one day. Although in some instances this would not have been necessary for operational reasons, it was desirable from the viewpoint of flushing the ships with non-contaminated water. Subsequent to BRAVO, lagoon operations were such that water in-take points and evaporators could be maintained at a fairly constant and reasonable level of activity by cold water treatment; however, intensities slowly rose in salt water pipe fittings and heads. Flushing the ships salt water systems in the open sea was of considerable aid in maintaining acceptable levels at such places. No activity was detected in the continual analysis of fresh water supplies past the evaporators. (See Tab J for further details relative to ship operation in contaminated lagoon waters.)

On the morning of 26 March a favorable forecast of H-Hour winds for the following day set in motion the entire pre-shot schedule of events again. This forecast gave east-northeast winds to approximately 8,000 feet, southerlies to about 12,000, southeasterlies to 20,000, southerlies to southwesterlies to 55,000 and east southeasterlies to easterlies above 55,000 feet. All units and external agencies were notified accordingly that ROMEO schedule was firm for 270630M.

Following the noon Command Briefings, CINCPACFLT was advised of the forecast 72-hour air particle trajectories for ten, thirty, forty and fifty thousand feet. Further, the advisory stated that no significant fall-out was forecast for populated Marshall Atolls and recommended no closure of air routes. It included a statement that no surface health hazard problems were forecast outside Area GREEN and that an intensive search was being conducted in this area plus a 240 NM wide sector out to 600 NM centered on true bearing 340°. (The sector search was scheduled and run again post-shot centered on 305° True from 220 NM to 600 NM from GZ. Starting at H-2 hours four search aircraft were used on parallel flight tracks, 60 NM coverage per aircraft, in advance of the cloud.) In addition, CINCPACFLT was requested to divert all shipping from the sector area GZ, 260° clockwise to 90° True to 450 NM. A statement was included that no known shipping was in this area.

At about 1400M a special advisory was issued to the British Sampling Unit on Kwajalein, including the forecast air particle trajectories and the forecast GZ H-Hour winds. The British Unit was informed that authority to penetrate the Danger Area would be given later in the scramble and routing instructions to be issued by CTG 7.4 approximately H plus 3½ hours. The British Unit was directed to file its flight plan through the Kwajalein Liaison Officer using this advisory as authority for ROMEO flights.

At approximately 1500M the surface and air RADEXES were issued as follows

Surface RADEX: True bearings from GZ 240° clockwise to 50° radial distance 90 NM for H to H plus 6 hours, plus a circular RADEX around GZ of 25 NM radius. It was recommended that the Control DDE move to true bearing 250° and 90 NM from GZ.

Air RADEX: H plus 1 hour, 10,000 feet and up (true bearings from GZ), 280° clockwise to 75° maximum distance 20 NM; 40,000 feet and up (true bearings from GZ): 270° clockwise to 90° maximum distance 35 NM. For H plus 6 hours, multiply distances by six.

At 1500M, in an effort to assist the Kwajalein permanent garrison, the P2V Patrol Squadron assigned to TG 7.3 and stationed at Kwajalein was directed to assume CASTLE Radsafe monitor responsibilities for Kwajalein from H to H plus 24 hours and to report results in excess of 10 mr/hr to the task force headquarters by Operational Immediate precedence. A similar arrangement was made for Wake Island; TG 7.4 was directed to set up a special monitor station for the period H to H plus 36 hours. (No contamination was subsequently detected on Wake.)

At the 1800M Command Briefing, the wind patterns observed and forecast being completely favorable, the decision to shoot the following morning was confirmed. At approximately 2300M a directive was passed to CTG 7.4 relative to the cloud tracking flights for the first twelve-hour period on shot day. Inasmuch as it had been decided during the interim period following BRAVO to attempt a better evaluation of the effect of the depth of tradewind on the resultant fall-out moving toward Eniwetok, two WB-29 cloud trackers were planned to operate in the racetrack holding pattern west of GZ, one at 10,000 feet, the other approximately midway between the surface and 10,000 feet. The directive consequently specified a flight by Wilson 2 from H plus 2 to H plus 14 hours from base to a three-hour holding pattern 50 NM west of GZ at 10,000 feet, thence to a 500 NM sector, limiting true bearings from GZ of 60° and 90° at 10,000 feet. Wilson 3 was directed to search from H plus 2 hours until released, in the holding pattern specified above, and at an altitude selected by the pilot to clear natural clouds, but not in excess of 5,000 feet.

A complete Command Briefing was held at midnight, at which all previous factors, advisories and decisions were confirmed. It was decided however, to re-check the winds at 0430M and just prior to shot time. The forecast fall-out plot by elliptical approximation is included in Inclosure 4.

The British Unit was again advised at H minus 6 hours relative to the latest changes in the forecast winds. Due to a small shift in the low level winds, the Control DDE was moved to 230° True, 90 NM from GZ. No change was recommended relative to the Task Force fleet location southeast of GZ at a minimum distance of 30 NM.

The late checks of the weather/radsafe conditions indicated a more favorable shot time wind pattern than forecast (i.e. deeper southerlies in the levels between the trades and 55,000 feet). Transient shipping contacts being favorable, ROMEO was detonated on a barge in approximately 110 feet of water in the BRAVO crater at 270630M March 1954, the first water surface shot in the history of U. S. atomic testing. No undue incident occurred to the embarked task force personnel and ships. Post-shot advisories were issued prior to H plus 30 minutes to the Chairman, AEC, C/S Army and CINCPACFLT as on BRAVO, indicating time of detonation and a general statement of safety of personnel.

At 1100M CTG 7.4 was directed to fly Wilson 4 on a search from base to the sector centered on Rongerik Atoll with limiting true bearings 60° and 90° at 10,000 feet to 500 NM, thence to 16N, 170E to 16N 162E to base. The latter vectored portion of this mission, and all similar missions on subsequent shots, was selected on the basis of the air particle trajectories and in order that the aircraft would pass through the forecast positions of the lower cloud corresponding to the time of arrival of the aircraft. This portion of the mission was essentially an attempt to verify the forecast as well as to sweep the area between Wake (and air routes through Wake) and GZ. The aircraft commander was authorized to shift the last turning point if required for range considerations. Wilson 4 was advised to anticipate light contamination on the northern half of the sector search and near 16N, 169E.

At 0930M on D day instructions were passed by CTG 7.3 to all fleet units to modify damage control measures at their discretion, to keep topsides wet and to remain alert to the possibility of early fall-out. This concern was precipitated by the early and ominous splash-out of the cloud at and above the tropopause and the consequent production of an over-running lip of the cloud to positions extending over the fleet. Due to the strong southerly wind flow below the tropopause, no contamination from the cloud lip was forecast for, or reached, the fleet.

By 1100M an alert advisory was issued to all task force units, stating that the H plus 3 hour preliminary damage survey indicated sites TARE through OBOE were not appreciably contaminated. For planning purposes R-hour (re-entry hour) was designated as 1200M. CTG 7.3 was directed to have the task force vessels stand-off the lagoon entrance at 1100M pending the outcome of the lagoon water survey at the anchorages. The advisory further stated that at R-hour unrestricted radsafe clearance would be declared for sites OBOE through TARE and for all air and water traffic south of TARE and NAN anchorages. All re-entry except OBOE through TARE and all air and surface traffic north of the anchorages would be placed under the control of the Radsafe CENTER of TG 7.1 at R-hour. Upon confirmation of R-hour, all units were directed to commence re-entry in accordance with previous instructions. Beginning with this shot, and for all subsequent shots, brief informal advance notice of R-hour plans was passed by voice to CTG 7.3 to facilitate rapid assembly and re-entry of ships.

At 1200M an advisory directive was issued to all units specifying that cloud tracking flights since H-hour indicated no radiation hazard to surface operations or to flight operations at any altitude below 20,000 feet south of Bikini and within 60 NM of GZ. The results of the preliminary lagoon water sampling were used as a basis for a statement that the TARE and NAN anchorages were below safe radiation limits. The advisory further stated that the H plus 4 hour radsafe/damage survey indicated OBOE clockwise through BRAVO and NAN had received no further contamination from ROMEO. R-hour was announced for 1300M at which time recovery operations would be controlled by the Radsafe CENTER of TG 7.1. Sites OBOE through BRAVO and all water and air traffic south of TARE and NAN anchorages were declared radsafe unrestricted. Swimming in the lagoon was prohibited until further notice.

Restricted water and air traffic north of the anchorages was declared subject to clearance by the Radsafe CENTER. All units were directed to commence re-entry to the RAN anchorages at 1300M in accordance with previous plans.

At 1200M CTG 7.3 advised all ships to execute re-entry at R-hour and to remain on one-half hour readiness until further notice.

During the morning cloud tracking aircraft made low intensity contacts of contamination moving to the southwest, and high intensity (2 r/hr) contacts at the north end of the racetrack holding pattern. This latter evidence became the basis for an alert message to the Eniwetok garrison indicating a westerly movement of contamination in the roentgen range located approximately 60 NM west-northwest of GZ. Although the contamination was calculated to pass to the north of Eniwetok, all personnel at that atoll were directed to remain on alert status until H plus 24 hours. No significant fall-out was subsequently experienced, a fact verified by a 1900M report from the Eniwetok monitoring system indicating 1 mr/hr maximum on FRED and ELMER and zero a URSULA. The low intensity contacts southwest of GZ were not considered significant for Ujelang.

Considerable use was made of data from the drone Liberty ships (YAG's 39 and 40) to evaluate the fall-out pattern. At H plus 106 minutes these ships were at 26 NM on bearing 283° True from GZ and on course 350° True, maintaining sufficient speed for steerage. The reported results of the non-washdown equipped YAG 40 were as follows:

H plus 155 minutes	3.0 r/hr
H plus 158 minutes	4.0 r/hr
H plus 160 minutes	4.2 r/hr
H plus 168 minutes	10.0 r/hr
H plus 190 minutes	28.0 r/hr
H plus 197 minutes	35.0 r/hr
H plus 225 minutes	46.0 r/hr

At 1300M YAG 40 was bearing 303° True from GZ at 40 NM. (This data above was originally reported a factor of 10 high, however, suspicions as to improper functioning of instrumentation, later confirmed, gave results as indicated above. These results, and later coordination with Project 2.5a sea fall-out collectors were extremely valuable in assessing the forecast significant fall-out pattern as an elliptical area oriented generally north and south to at least 50 NM from GZ.

At approximately 1800M the USS EPPERSON, DDE, on security patrol 50 NM northwest of Bikini, reported fall-out giving average readings of 25 mr/hr and maximums of 100, retiring from the area at 1900M due to the high intensities.

Cloud tracking flights on shot day were routine and in accordance with plan. (See inclosure attached reference Air Radsafe Operations for ROMEO.) Excellent early verification of the forecast fall-out pattern was obtained as these efforts continued through the afternoon and the night of shot and shot plus one day. Wilson flights subsequent to H plus 24 hours were canceled since it soon became apparent that further efforts were unnecessary.

In accordance with plan, CINCPACFLT was advised at 2000M on shot day of the current radsafe situation. This advisory consisted of the revised ten, thirty and forty thousand foot forecast trajectories, a statement that no significant fall-out was forecast for populated Marshall Atolls, the proposed NYKOPO Flight Able scheduled for 28 March, that no health hazard problems were forecast for surface routes except between true bearings from GZ, 270° clockwise to 90° to a distance of 450 NM and that possible significant fall-out existed in Area GREEN. A statement was included that no known shipping was in the forecast fall-out area.

At 2000M, 28 March, the second and final CINCPACFLT post-shot advisory included statements that CINCPACFLT would be further advised as circumstances require, that no significant change was forecast for the 72-hour cloud trajectories, that no health hazard problems were existent or forecast from ROMEO and that NYKOPO Flight Able flown ROMEO plus one day indicated maximum intensities less than 10 mr/hr from ROMEO.

At 0130, 29 March, information was received by CTG 7.1 from TG 7.1 personnel at Bikini that all ships there were observing approximately 15 mr/hr intensities, and that the remote instrument on TARE was reading 85 mr/hr. Vertical windward surfaces on ships were indicating approximately two times as high as other surfaces. From this it was concluded that the ships were experiencing air fall-out and not getting increased readings from water contamination. Information from TG 7.3 indicated that the fleet would depart Bikini in a southeast direction at dawn if the fall-out continued. As a result of conference with CTG 7.1 and the Task Force Weather and Radsafe officers, it was agreed that the contamination was the result of an air flow to the east and south by the thirty thousand foot level, occurring at some distance to the east of Bikini and eventually allowing contamination to be brought back to the west by the trade winds. It was estimated that the contamination was of the aerosol-type and that approximately half of the observed intensities were due to a "shine" affect from a transiting volume of contaminated air. Consequently, it was agreed that CTG 7.1 would recommend no departure of ships in anticipation of cessation of the fall-out and "shine" within a few hours.

At 0230M, 25 March, CTG 7.1 received additional information to the effect that use of wash-down systems had reduced readings by a factor of two. The advisory mentioned the EPPERSON contact of 25 mr/hr, 50 NM northwest of Bikini and noted no significant change on the return trip to Bikini by the EPPERSON. Air concentration was reported as 0.02 microcuries per cubic foot, activity distributed over all stages of the cascade impactor with the highest reading on the final stage.

At 0430M, 29 March, information was received from CTG 7.3 that fall-out apparently had ceased, that after wash-down, the highest readings were 20 mr/hr average, 27 mr/hr maximum on the RENSHAW and that the TARE helicopter pad read 48 mr/hr at 0315M. The advisory indicated that active radsafe measures were being continued as necessary and all ships resuming 2-hour notice for getting underway

Based on the Bikini experience and the forecast 72-hour air particle trajectories, NYKOPO Flight Able was scheduled for 30 March to assess the effects of secondary fall-out on the atolls east of Bikini.

On 30 March a report was received from CTG 7.3 to the effect that no early fall-out was received by any ship except the experimental YAG's, that nearly all ships and boats received light contamination from fall-out occurring approximately 40 to 48 hours after shot time, that average readings of 25 mr/hr were reduced due to decontamination and decay, that personnel exposures were negligible compared with BRAVO (estimated average additional individual exposures due to ROMEO was approximately 50 mr), and that, although the western quarter of the lagoon was still highly contaminated, it was doubtful if lagoon contamination would become a serious problem to ships. The above information was passed on 31 March to CINCPACFLT in accordance with a post-BRAVO request by CINCPACFLT for such information.

On 31 March information was received from the TG 7.3 unit on Kwajalein to the effect that 9 mr/hr maximums were observed on the windward side of tree trunks, 1 to 3 mr/hr average on beaches and 1 to 4 mr/hr average on windward sides of buildings. The average Kwajalein background prior to 31 March was 0.05 mr/hr. The advisory further stated that aircraft on training flights in the local area were concentrating contamination reaching maximum values of 20 mr/hr on engines. (Note: Approximately the same values were observed at Eniwetok by the evening of 29 March. Values were 5 mr/hr average, with 15 mr/hr maximum on windward surfaces.)

On 1 April a special radsafe advisory was dispatched to ComNavSta Kwajalein to reassure the garrison relative to the light fall-out experienced. This advisory noted that the fall-out on Kwajalein was of a degree equivalent to that experienced on Eniwetok and considered insignificant from a health standpoint. As a precautionary measure, it was suggested that Kwajalein water catch basins be examined carefully, the first run-off of the next rain be isolated and that a pint sample be taken for analysis. The facilities of the task force were made available (and accepted) for this analysis. (Subsequent analysis indicated no activity in the five samples taken except the one from Open Storage Tank No. 10 which read 4.85×10^{-4} microcuries per milliliter.)

On 3 April in response to a request from Kwajalein the above advisory was re-quoted to include CINCPACFLT, and further stated that the Task Force Staff Surgeon would visit Kwajalein to establish suitable operating procedures for future shots. (No further difficulties arose for the remainder of the CASTLE series.)

On 9 April information was received that wire services were carrying Tokyo stories reporting two Japanese fishing vessels outside the Danger Area arriving at port with radioactive tuna. These stories indicated that some of the catch was destroyed, vessels reportedly radioactive, but no illness reported on the crews. No official confirmation was received, and from the press stories the contamination appeared to be slight. Considering time and distance factors, the contamination could have come from ROMEO at fishing grounds to the east northeast of GZ.

On 9 April CINCPACFLT was advised of the following apparent increases (by NYKOPO Flight Able) experienced by Marshall Atolls as a result of ROMEO (10 mr/hr and above on 1 April): Ailinginae 20, Rongelap 50 and Rongerik 22. CINCPACFLT was advised that no special action was required.

Since the activities of the AEC New York Operations Office had a considerable impact on task force post-shot off-site radsafe operations, the final report of this agency is suggested as additional information on the long-range aspects of UNION.

8 Incl
1. An evaluation of Weather Forecasts for ROMEO
2. Tabulation of ROMEO Pre-shot and Post-shot Winds from Task Force Station
3. Forecast and Computed ROMEO Air Particle Trajectories.
4. ROMEO Ground Zero Hodographs
5. ROMEO Shot Day Ground Radiation Intensitiss On-site
6. Air Radsafe Operations for UNION
7. Preliminary Results NYKOPO Airborne Monitoring Flights o/a 27 Mar 1954
8. Summary of the Status of Transient Shipping in the PPG Area o/a 27 Mar 1

AN EVALUATION OF WEATHER FORECASTS FOR ROMEO

1. Summary of weather immediately prior to R-Day: There had been considerable stratocumulus and some shower activity near Eniwetok on the evening before. For the ten days preceding R-Day cirrus conditions had been broken to overcast throughout the Marshalls. Very persistent easterly winds had prevailed during the preceding week except for a short interval around 21 March.

2. The Weather Forecast: 3/8 cumulus, scattered patches stratocumulus, 7/8 cirrus, scattered showers.

a. Observed weather: 2/8 cumulus, no stratocumulus, 3/8 cirrus, no showers at shot site.

b. Comments on weather: Wilson 1 (reconnaissance aircraft near shot site) reported 6/8 to 7/8 cirrus from 0155M to 0350M. At 0405M the cirrus decreased to 4/8 and then remained 3/8 or less coverage until the device was detonated. Showers were reported by GCA at 1016M, 16 miles southeast of Eniwetok and by aircraft 60 miles west of Bikini at 1133M and 1153M.

3. The Wind Forecast:

HEIGHT	H-48	H-33	H-24	H-14	H-8	H-4	OBSERVED BIKINI (H hour)
90M	E/50	ESE/50	090/40	100/45	110/45	110/45	
80M	E/35	ESE/35	110/30	110/20	110/35	110/35	
70M	L&V	ESE/20	L&V	L&V	L&V	L&V	080/22
60M	L&V	L&V	130/08	L&V	180/10	180/10	270/13
55M	L&V	ESE/15-25	150/10	110/10	170/15	170/15	270/15
50M	L&V	ESE/15-25	180/11	130/15	160/20	160/20	140/15
45M	ESE/15-25	ESE/15-25	200/14	180/18	200/23	200/23	200/05
40M	ESE/15-25	ESE/15-25	230/16	190/10	180/12	180/12	200/36
35M	ESE/15-25	ESE/15-25	200/15	180/09	180/10	180/10	180/18
30M	ESE/15-25	ESE/15-25	180/14	140/10	150/10	150/10	220/08
25M	ESE/15-25	ESE/15-25	160/15	130/25	130/20	130/20	170/08
20M	ESE/15-30	ESE/15-25	140/15	110/20	100/25	100/25	100/20
15M	ESE/15-30	E/10-20	110/10	120/17	110/20	120/20	100/10
10M	ENE/15-25	ENE/10-20	200/08	120/12	150/11	150/11	180/08
8M	ENE/15-25	ENE/10-20	090/10	110/10	090/08	120/10	170/07
6M	ENE/15-25	ENE/10-20	080/10	100/10	080/08	080/08	080/05
4M	ENE/15-25	ENE/10-20	080/15	090/15	080/10	070/16	060/11
2M	ENE/15-25	ENE/10-20	070/20	090/20	070/12	060/18	070/14
SFC	ENE/15-25	ENE/10-20	070/18	080/15	070/12	070/12	040/10

a. Comments on Winds:

(1) The Bikini winds were observed by gun laying radar equipment aboard the USS CURTISS. This ship was approximately 30 miles south of ground zero. 38% of the forecast wind direction were within 10 degrees of the observed, and 57% were within 20 degrees. With two exceptions, those that deviated more than 20 degrees had speeds of less than 9 knots. The two exceptions were at the 55,000 and 60,000-foot levels immediately below and above the tropopause.

(2) 45% of the wind forecast speeds deviated 4 knots or less from the observed, and 81% deviated 10 knots or less. The maximum error was 24 knots at 40,000 feet. The wind at this level increased from 19 knots at 0300M to 36 knots at 0600M - a reading verified by a wind observation obtained by an aircraft at 39,300 feet - then dropped to 13 knots at 0900M. A fluctuation such as this could go unnoticed in most cases. It was detected only because upper wind observations were being taken every three hours.

ROMEO

Date 27 MAR 1954 Time 0600 L

Clouds lower 2/8 CU Base 2500 Tops 5,000 Middle NONE Base

3/8 OF ~~CIRRUS~~ STRATUS Visibility 15 Miles

Sea Level Pressure 1012.4 Mb Wind direction 040 degrees Velocity 10 Kts

Surface temp 80 °F Dew Point 72 °F Humidity 77 % Vapor pressure .783

Local weather PARTLY CLOUDY Remarks NO. SHOWERS OBSERVED

Latest winds aloft taken on CURTISS Position BIKINI Time 0600

ALTITUDE	DEGREES	KNOTS	PRESSURE	TEMP	DEW POINT	REL. HUMIDITY
Surface	040	10	1012.4 Mb	26.7 °C	22.2 °C	77 %
1,000 Ft						
1,500						
2,000	070	14	944	21.5	18.2	79
3,000						
4,000	060	11	878	17.8	14.0	76
5,000						
6,000	080	05	817	14.0	8.0	58
7,000(6900)			790	12.5	4.0	44
8,000	170	08	760	14.8	-7.7	21
9,000						
10,000	180	08	706	13.0		
12,000	150	10	656	8.8		
14,000	100	10	608	5.2		
16,000	090	15	565	1.1		
18,000	100	17	524	-3.5		
20,000	100	20	484	-7.0		
25,000	170	14	397	-14.2		
30,000	220	08	324	-27.0	-35.0	46
35,000	180	18	259	-39.5		
40,000	200	36	206	-52.5		
45,000	300	05	163	-64.3		
50,000	140	15	125	-75.0		
55,000	270	15	96	-82.2		
60,000	270	13		-77.2		
65,000	320	10		-70.5		
70,000(67,000)	080	22		-66.3		
75,000						
80,000						
85,000						
90,000						
95,000						
100,000						
105,000						
110,000						
115,000						
120,000						
125,000						
130,000						
135,000						
140,000						
145,000						
150,000						

REMARKS: CORRECTED COPY,
DESTROY ALL OTHERS.

BIKINI-ROMEO SHOT, 0630M, 27 MARCH 1954

LEVEL	H-6 hours	H-4 hours	SHOT	H+3 hours	H+9 hours
Surface	0716	0612	0410	0710	0717
2000	0619	0615	0714	0715	0716
4000	0618	0617	0611	0909	1118
6000	0910	0705	0805	1011	1413
8000	1411	1112	1708	1405	1710
10000	1612	1515	1808	1805	2005
12000	1310	1413	1510	1410	1507
14000	1112	1011	1010	1011	1115
16000	1018	0922	0915	0919	0917
18000	0921	0920	1017	1019	1026
20000	1122	0923	1020	1224	0815
25000	1315	1414	1714	1806	2002
30000	1002	2205	2208	1304	1728
35000	1911	1213	1818	1817	2213
40000	1914	1919	2036	1913	2907
45000	2027	2124	3005	2509	2015
50000	1613	1812	1415	1519	1517
55000	1512	1611	2715	2010	1704
60000	2313		2713		2413
65000	2915		3210		
70000			0822		

ENIWETOK-ROMEO SHOT, 0630M, 27 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+10 hours
Surface	0516	0516	0512	0614	0614
2000	Missing	0716	0716	0720	0722
4000	Missing	0714	0716	0717	0716
6000	0711	0812	0710	0810	0910
8000	0708	0807	1011	1111	1208
10000	0911	1112	1109	1208	1309
12000	1413	1510	1510	1511	1211
14000	1211	1214	1116	1412	1117
16000	1221	1213	1115	1212	1020
18000	1223	1122	1127	1024	1021
20000	1221	1022	1127	1223	1223
25000	1312	1113	1712	1422	1711
30000	1303	Calm	1810	1602	1709
35000	1606	1610	1821	1412	2913
40000	1719	1912	2426	2605	2210
45000	1816	1807	2312	2405	1926
50000	1529	1520	1512	1622	1617
55000	3307	3209	2008	1904	1716
60000	1613		3219	3110	2908
65000	3414		2705	2805	1908
70000	1005		0805	0807	1603
75000	1406		1113	1118	0810
80000	1319		1129	1239	1237
85000					1048

KUSAIE-ROMEO SHOT, 0630M, 27 MARCH 1954

LEVEL	H-9 hours	H-3 hours	SHOT	H+3 hours	H+10 hours
Surface	0705	0903	Calm	0604	0904
2000	0919	1116	0815	0719	0614
4000	1018	1118	0917	0819	0915
6000	1015	1112	0920	0821	1015
8000	0814	1013	0918	0724	1217
10000	1014	1012	1010	1112	1214
12000	1019	1218	1215	1118	1014
14000	1123	1122	1225	1122	0917
16000	1325	1218	1224	1222	1122
18000	1130	1016	1223	1226	1021
20000	1128	1124	1125	1222	1120
25000	1123	1116	1223	1324	1127
30000	1125	1123	1312	1417	1319
35000	1126	1205	1318	1524	1625
40000	1222	1335	1628	1321	1533
45000	1223	1335	1734	1326	1432
50000	1125	1223		1339	1430
55000	2506				3006
60000	1304				2712
65000	2935				3017
70000					1408
75000					1133

KWAJALEIN-ROMEO SHOT, 0630M, 27 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0511	0710	0508	0308	0513
2000	0720	0816	0916	0920	0817
4000	0714	0612	0716	1016	0810
6000	0810	0913	0917	1213	1406
8000	0908	1105	1213	1309	1408
10000	1404	1109	1113	1210	1409
12000	1210	1214	0917	1115	0914
14000	1118	1218	1218	1122	1120
16000	1224	1224	1118	1021	0925
18000	1128	1120	1112	0923	1024
20000	1226	1221	112[illegible]	1119	1129
25000	1321	1212	1310	1213	0810
30000	1211	1307	1106	1110	1006
35000	1421	1615	1916	2312	2017
40000	1714	1615	2022	1919	2117
45000	1610	1409	1615	1624	1625
50000	1125	1224	1427	1623	2503
55000	1712	1325	2617	2912	2712
60000			2410	2708	2417
65000			3018	3108	2517
70000			0410		0922
75000			1245		0834
80000			1142		0951
85000			1054		1062
90000			1172		1053

MAJURO-ROMEO SHOT, 0630M, 27 MARCH 1954

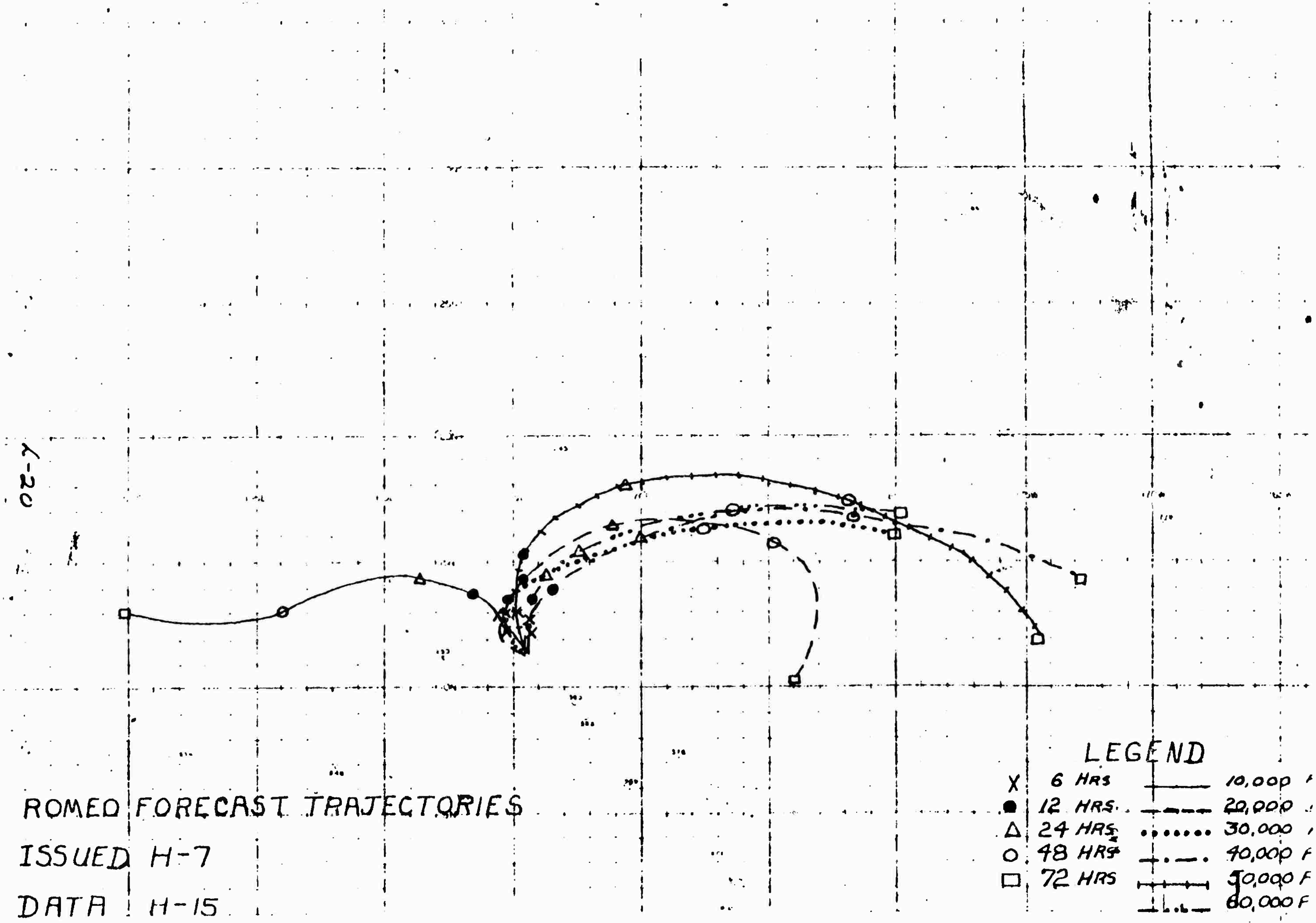
LEVEL	H-9 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0608	0608	0417	0609	0609
2000	0711	0514	0512	0624	0522
4000	1111	0806	0811	0720	0621
6000	1211	0710	0710	0717	0813
8000	1310	1209	0709	0911	0813
10000	1312	1210	1108	0611	0614
12000	0911	1110	1306	0612	0512
14000	0815	1110	1409	0813	0914
16000	0822	2919	0908	0614	0821
18000	0822	Missing	0712	0618	0929
20000	0821	1020	0715	1022	0924
25000	1116	1014	1014	1221	0611
30000	0909	0910	0507	0207	0811
35000	1515	1214	1111	1119	1215
40000	1420	1416	1212	1126	1317
45000	0915	0909	1214	1512	1020
50000	0718	0716	1211	0315	0806
55000	1411	1812	2316	2119	2218
60000			2609	2911	2616
65000			2813	2923	2609
70000			0908	0827	0836
75000			0838	0852	0851
80000			0847	0861	0756
85000			0754	0970	0859
90000			0846	0863	0865
95000			0742		
100000			0840		

PONAPE-ROMEO SHOT, 0630M, 27 MARCH 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+4 hours	H+9 hours
Surface	Calm	0905	0903	0903	0905
2000	0911	0916	0727	0721	0722
4000	1120	0914	0824	0824	0723
6000	1212	1112	1014	0918	0810
8000	1103	1206	1308	1508	1504
10000	0911	1110	1605	1107	1213
12000	0919	1111	1010	1007	1016
14000	0911	1112	1111	1009	1119
16000	1014	1118	1215	0913	1121
18000	1129	1128	1229	0916	1118
20000	1137	1132	1230	0914	1121
25000	1114	1123	1126	1320	1113
30000	1114	1215	1319	1017	1112
35000	1220	1115	1228	1120	1113
40000	1220	1219	1228	1428	1427
45000	1336	1229	1457	1440	1331
50000	1336	1344	1445	1220	1348
55000	3009	2707	1445	0608	1310
60000		2907		2511	3015
65000		3129		2916	3113
70000		1125		1410	1309
75000		1050		1045	1246
80000		0763		0862	1244
85000		0961		0969	
90000		0952		0866	
95000		0956		0880	
100000				1084	
105000				1087	

RONGERIK-ROMEO SHOT, 0630M, 27 MARCH 1954

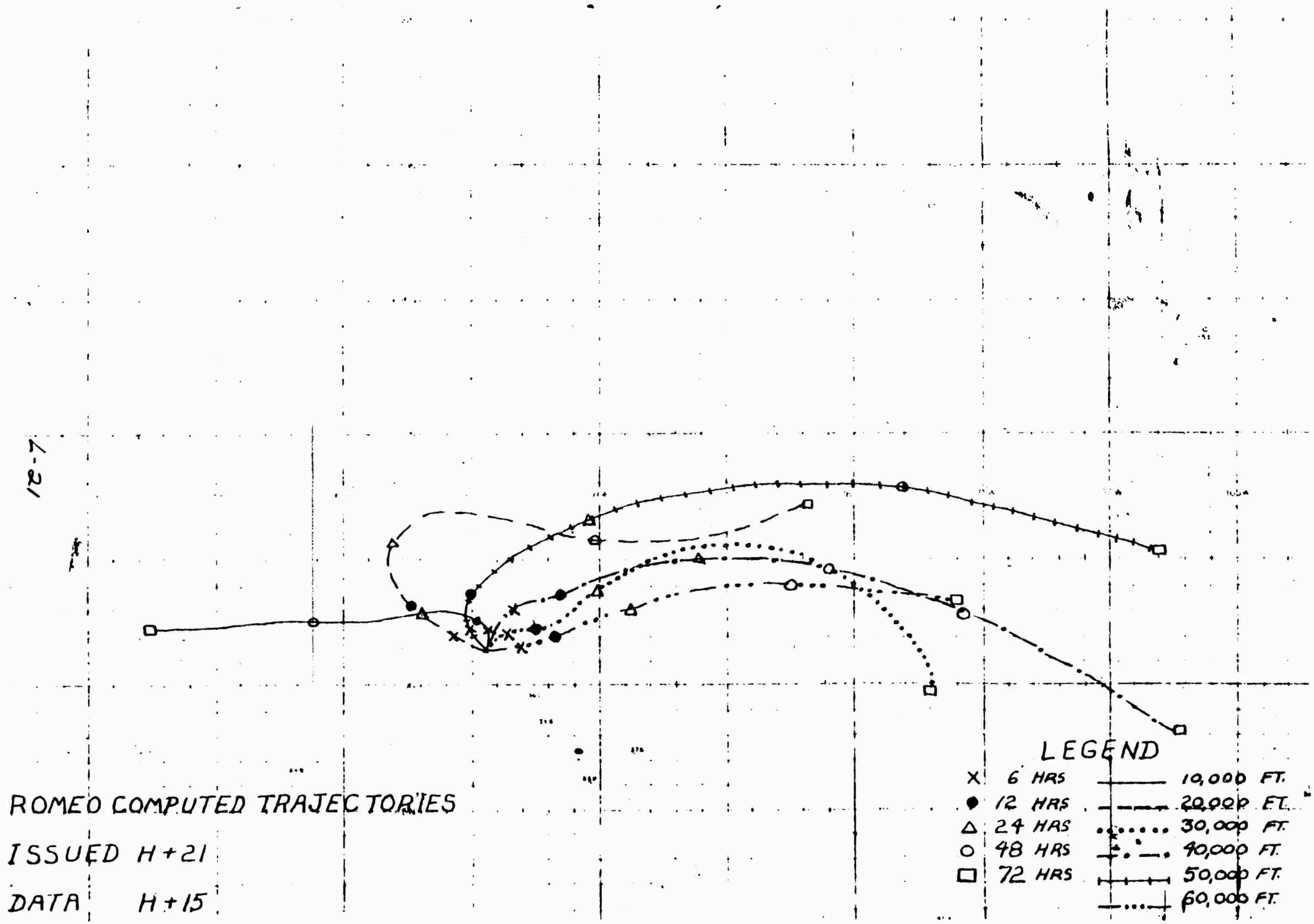
LEVEL	H-16 hours	H-14 hours	SHOT	H+3 hours	H+6 hours
Surface	0511	0709	No additional runs made.		
2000	0712	0811			
4000	0708	0605			
6000	0904	1804			
8000	1916	1912			
10000	0717	1815			
12000	1616	1815			
14000	1419	1215			
16000	1015	1217			
18000	1025	1025			
20000	1025	1025			
25000	1122	1228			
30000	1911	1213			
35000	1911	1807			
40000	2013	1615			
45000	1911	2309			
50000	1208	1813			
55000	1321	1409			
60000	2409	1211			
65000	3013				
70000	1704				
75000	1216				
80000	1331				
85000	1231				

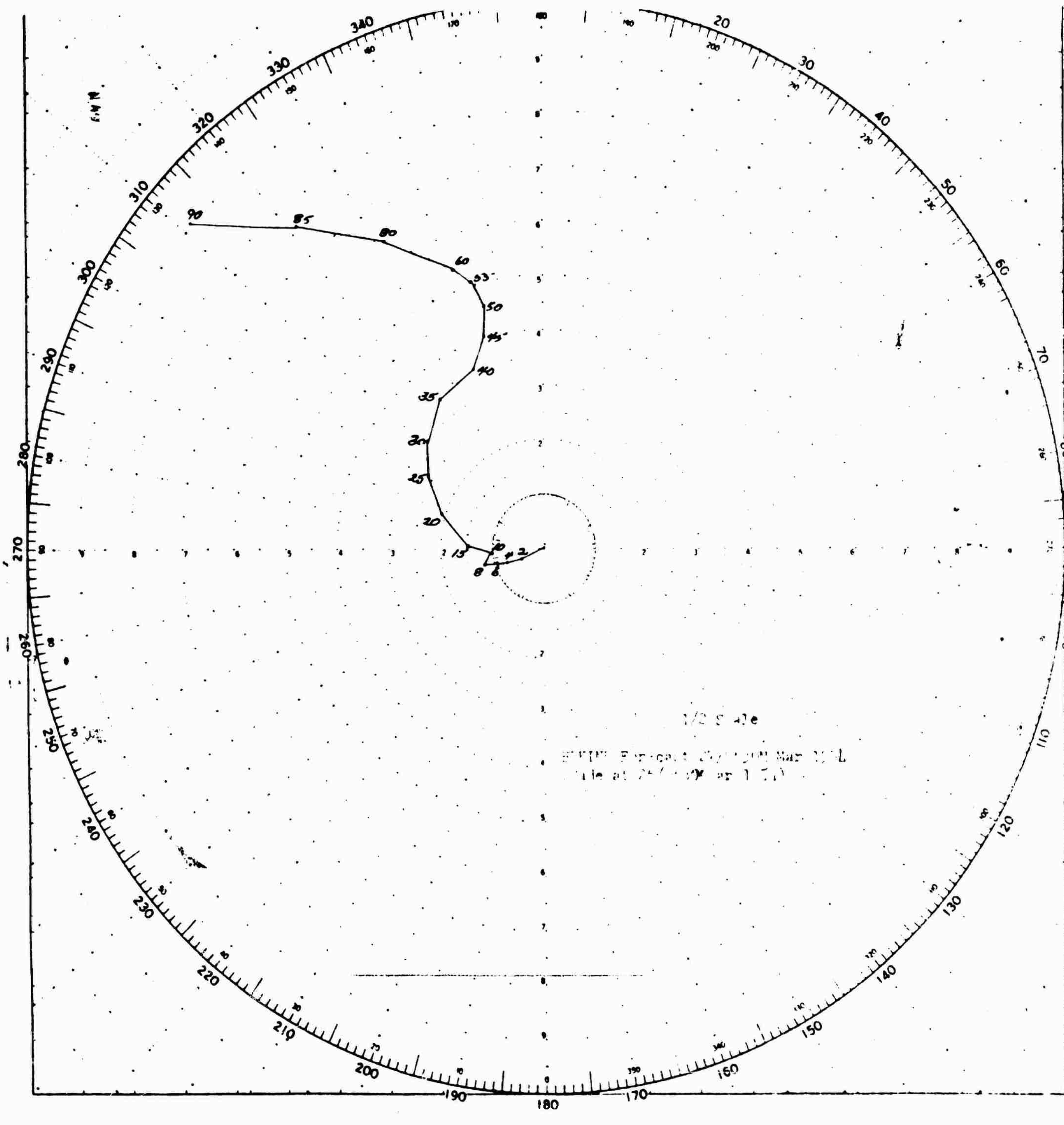


ROMEO FORECAST TRAJECTORIES

ISSUED H-7

DATA H-15


ROMEO COMPUTED TRAJECTORIES
ISSUED H+21
DATA H+15
LEGEND
× 6 HRS
● 12 HRS
△ 24 HRS
○ 48 HRS
□ 72 HRS
10,000 FT.
20,000 FT.
30,000 FT.
40,000 FT.
50,000 FT.
60,000 FT.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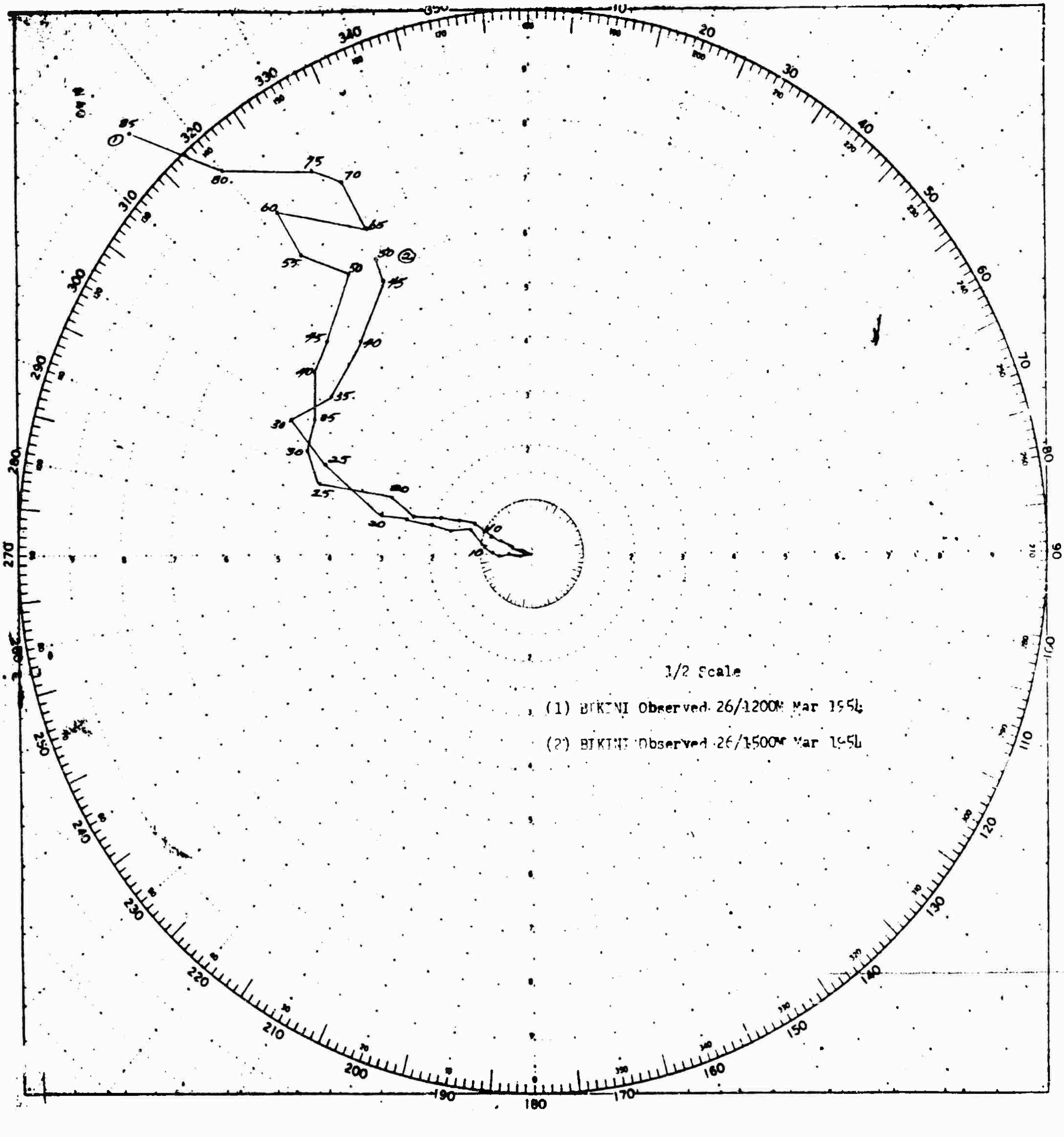
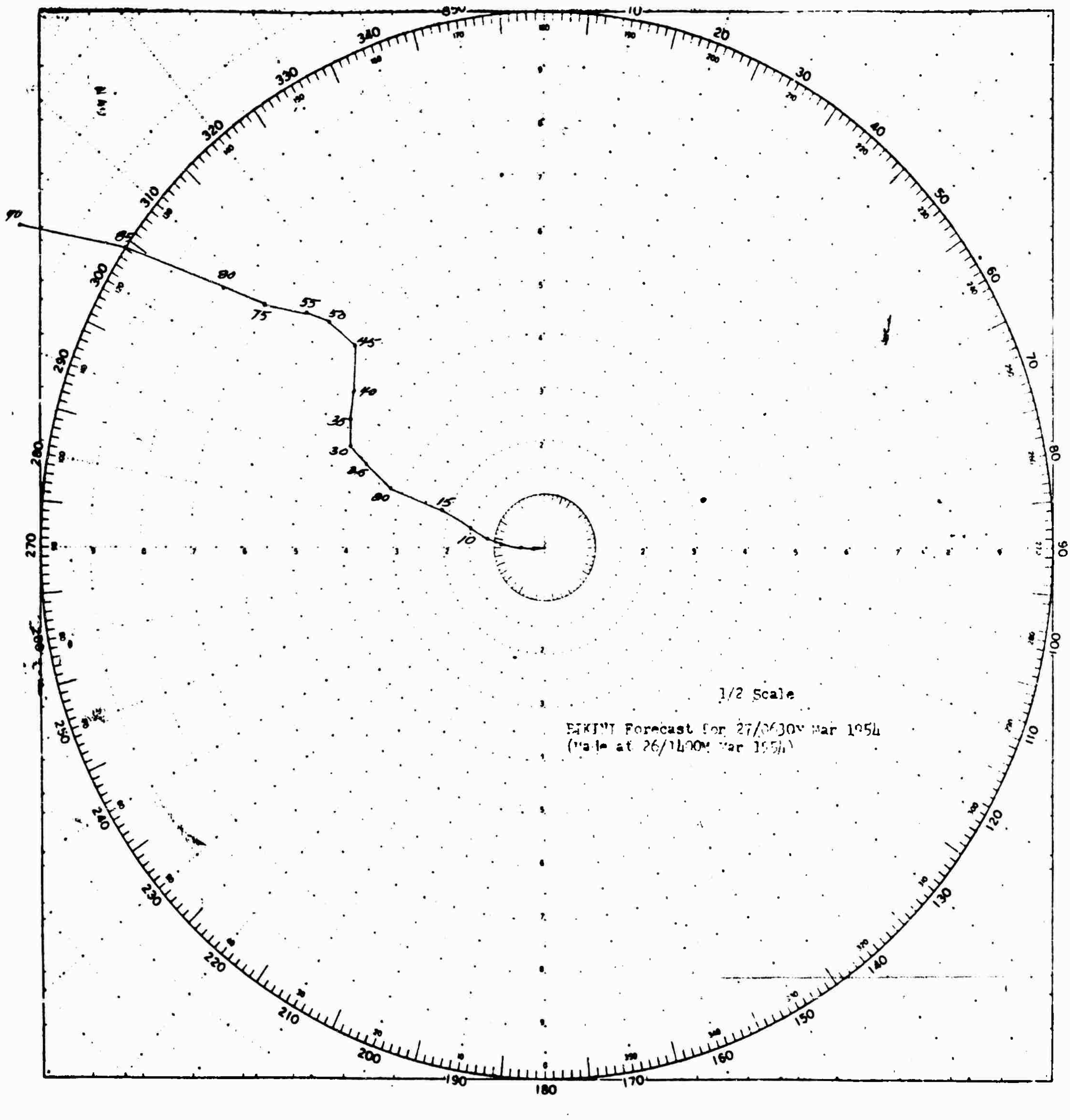
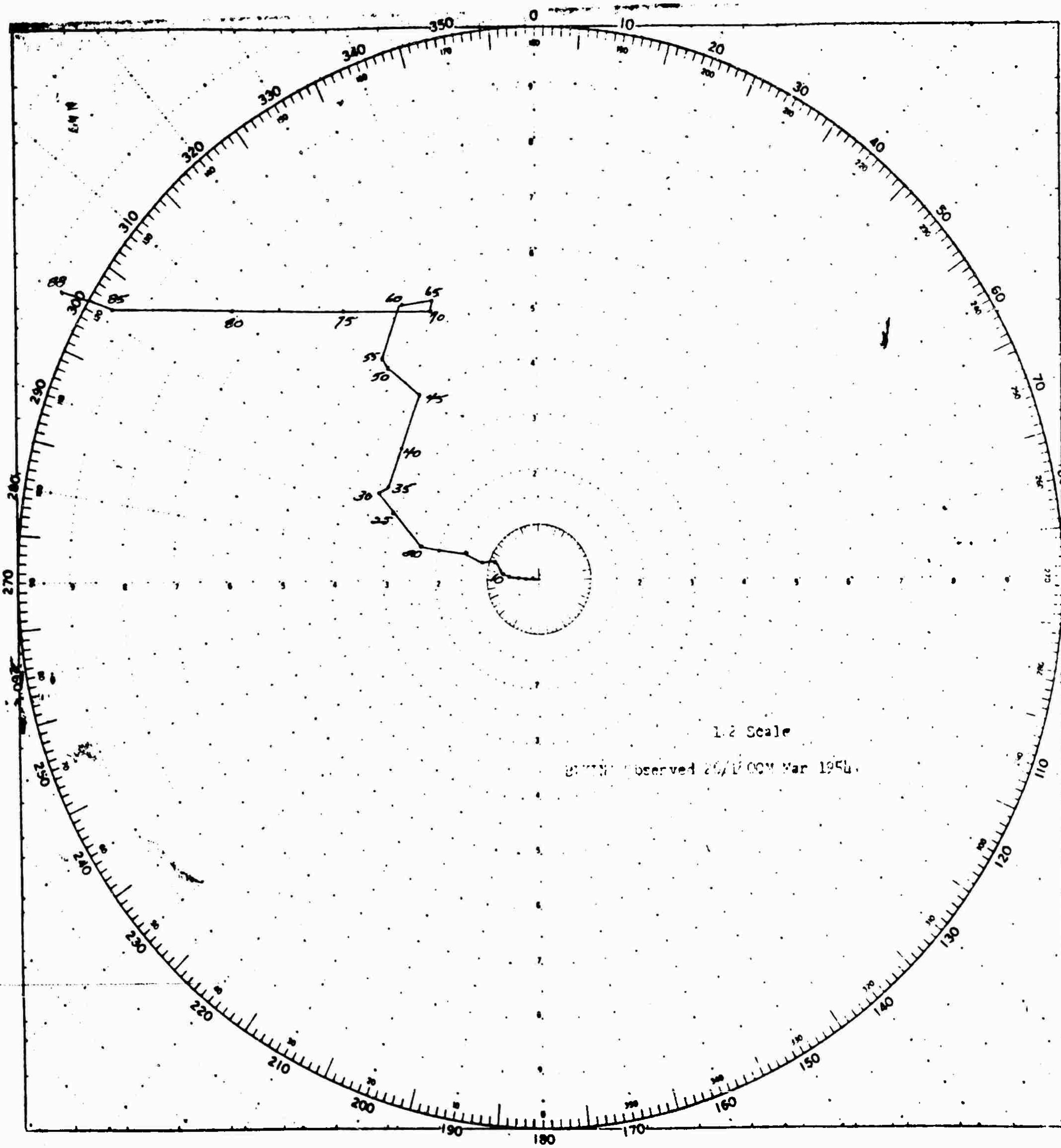
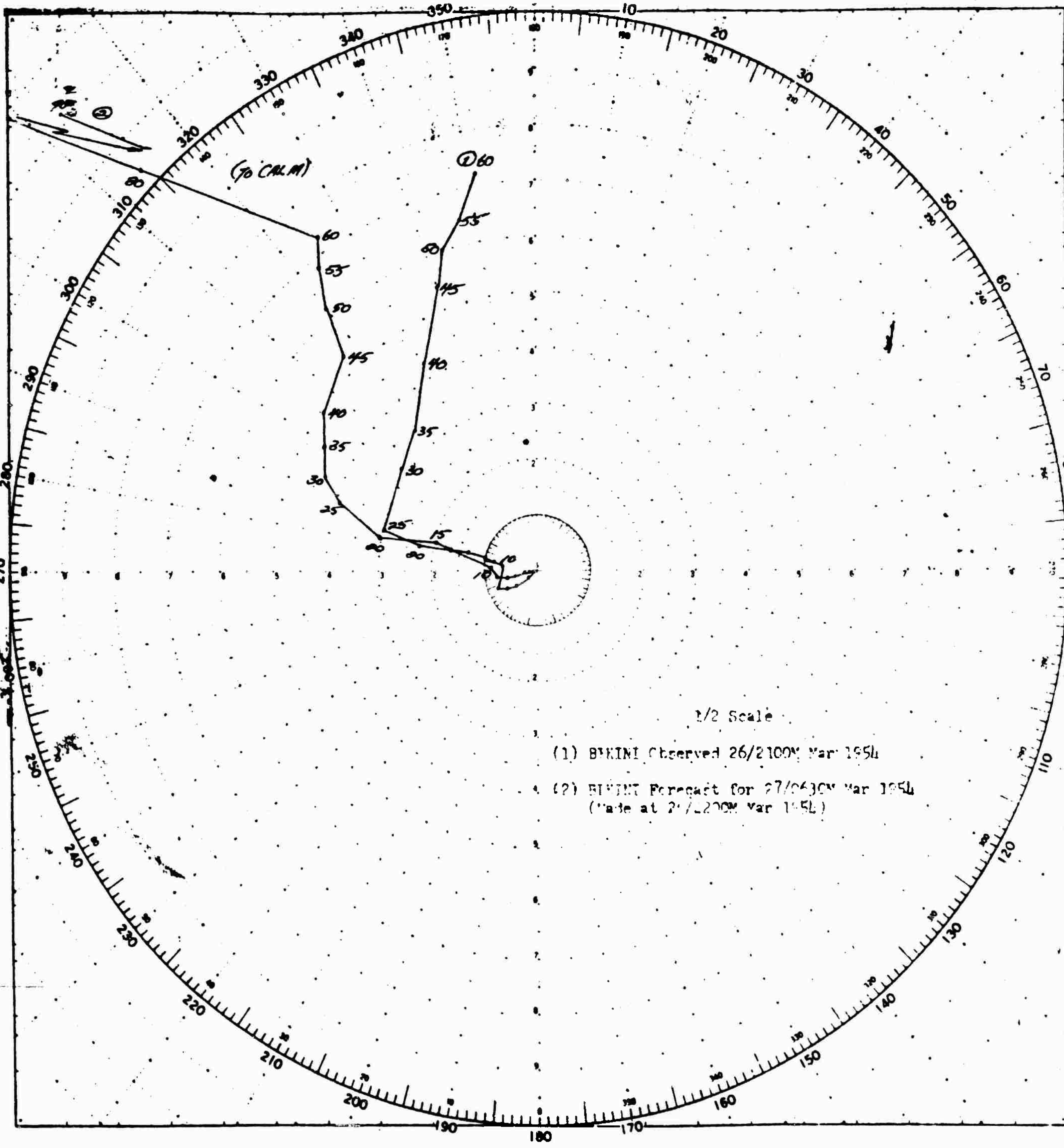
1/2 Scale


1/2 Scale
(1) BIKINI Observed 26/1200M Mar 1954
(2) BIKINI Observed 26/1500M Mar 1954


1/2 Scale
BIKINI Forecast for 27/0630M Mar 1954
(Made at 26/1400M Mar 1954)


1:2 Scale
observed
Mar 1954

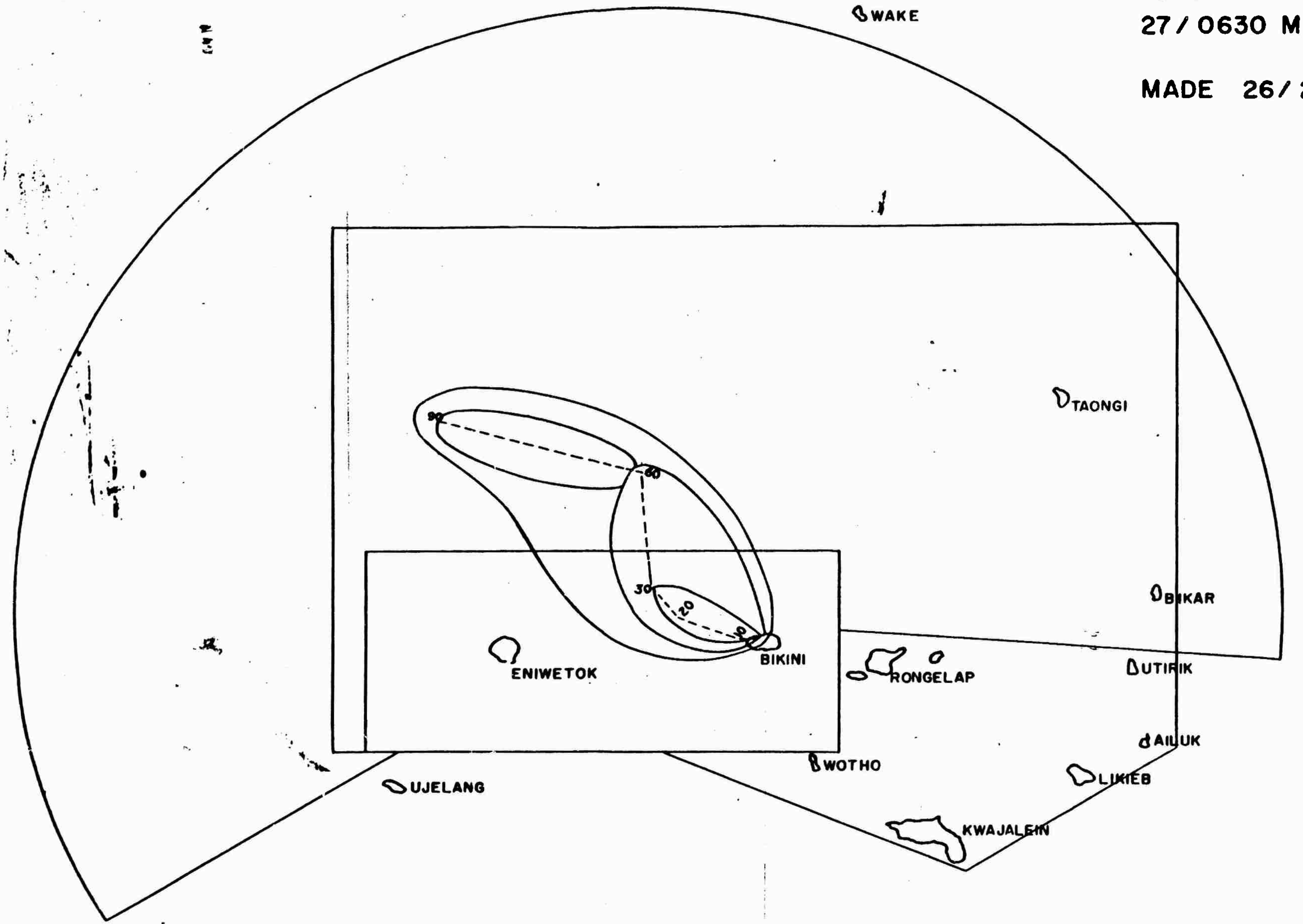


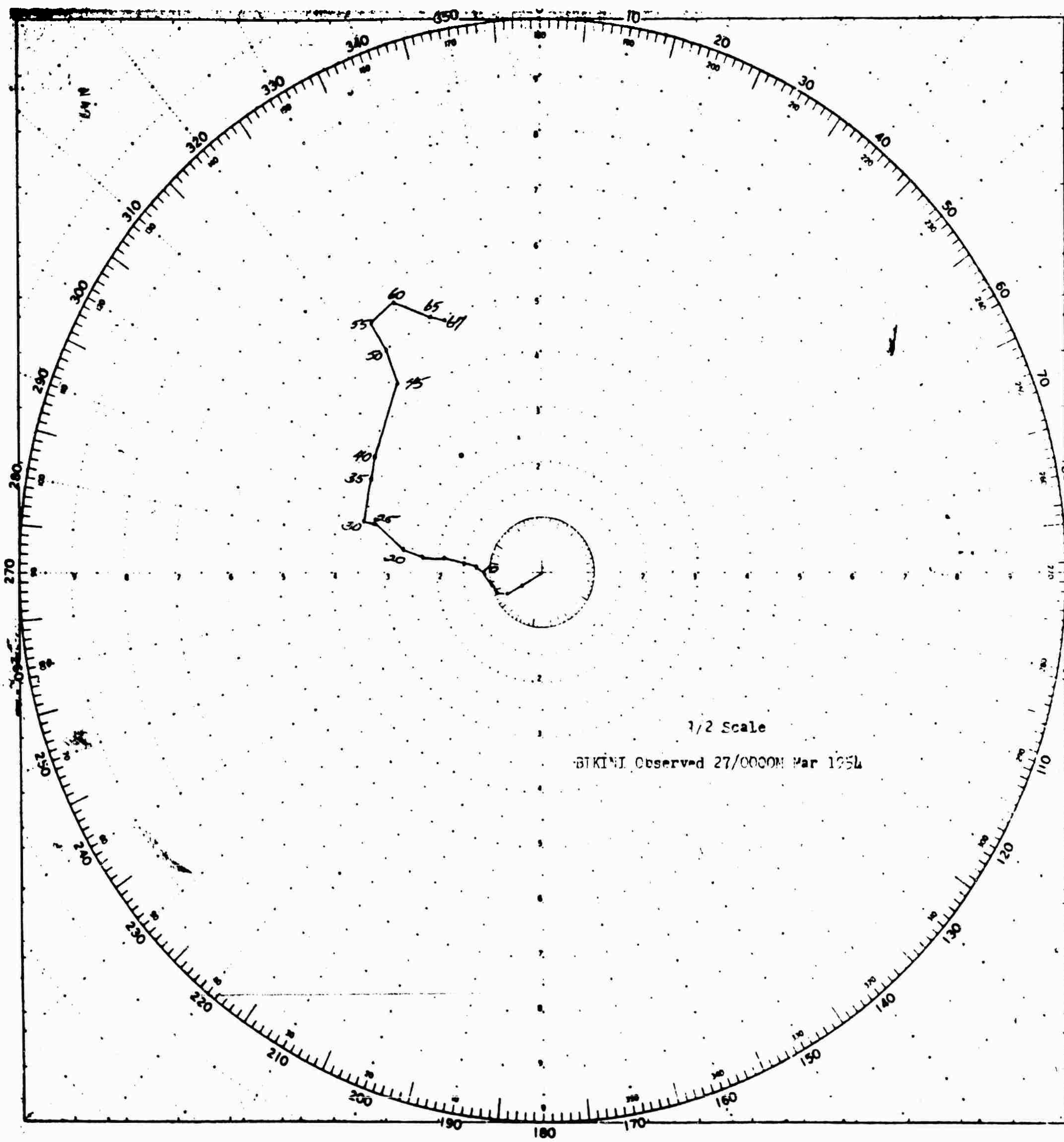
1/2 Scale
(1) BIKINI Observed 26/2100M Mar 1954
(2) BIKINI Forecast for 27/0630M Mar 1954
(To CALM)

ROMEO

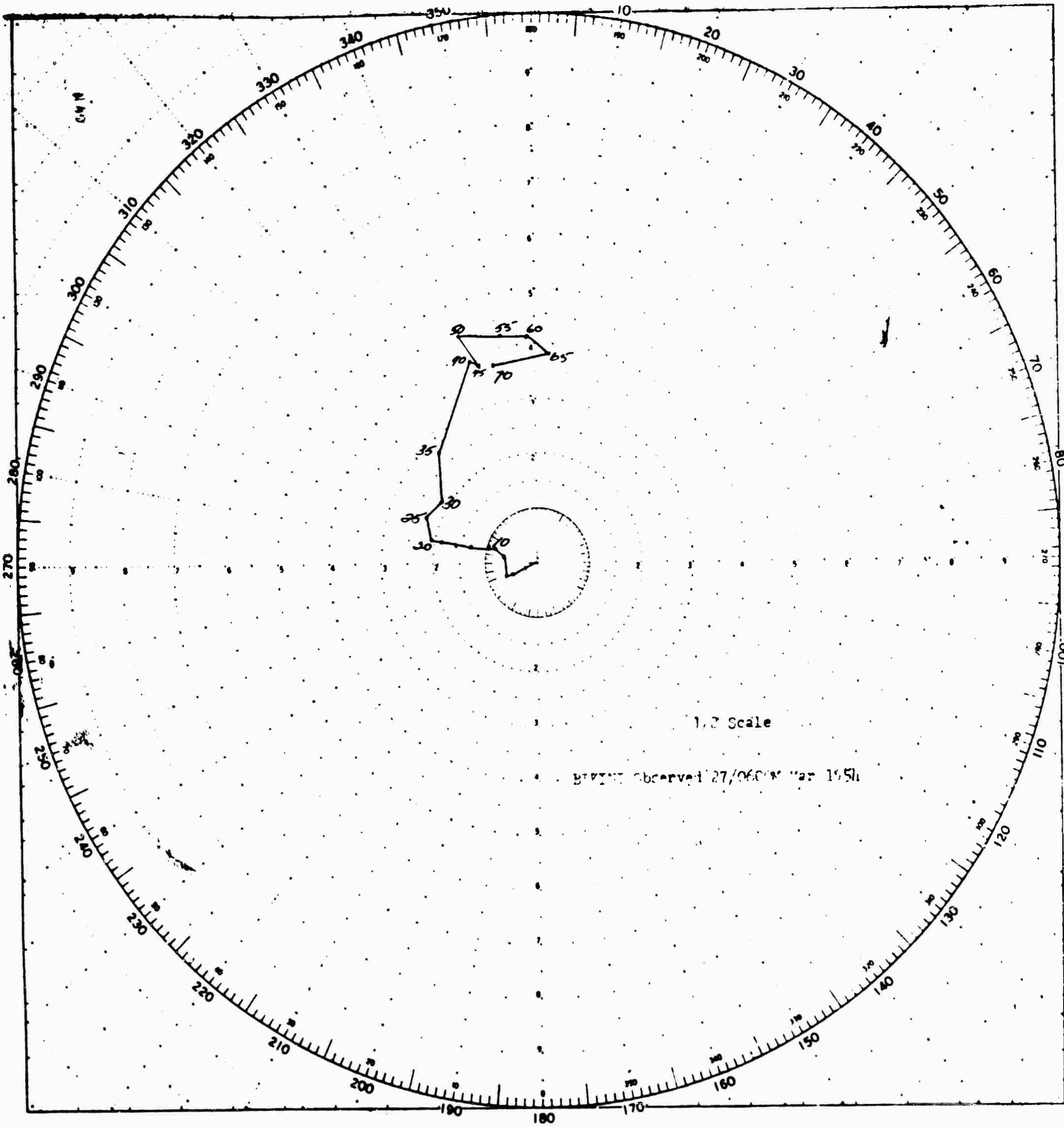
FORECAST FOR
27/0630 M MARCH 54

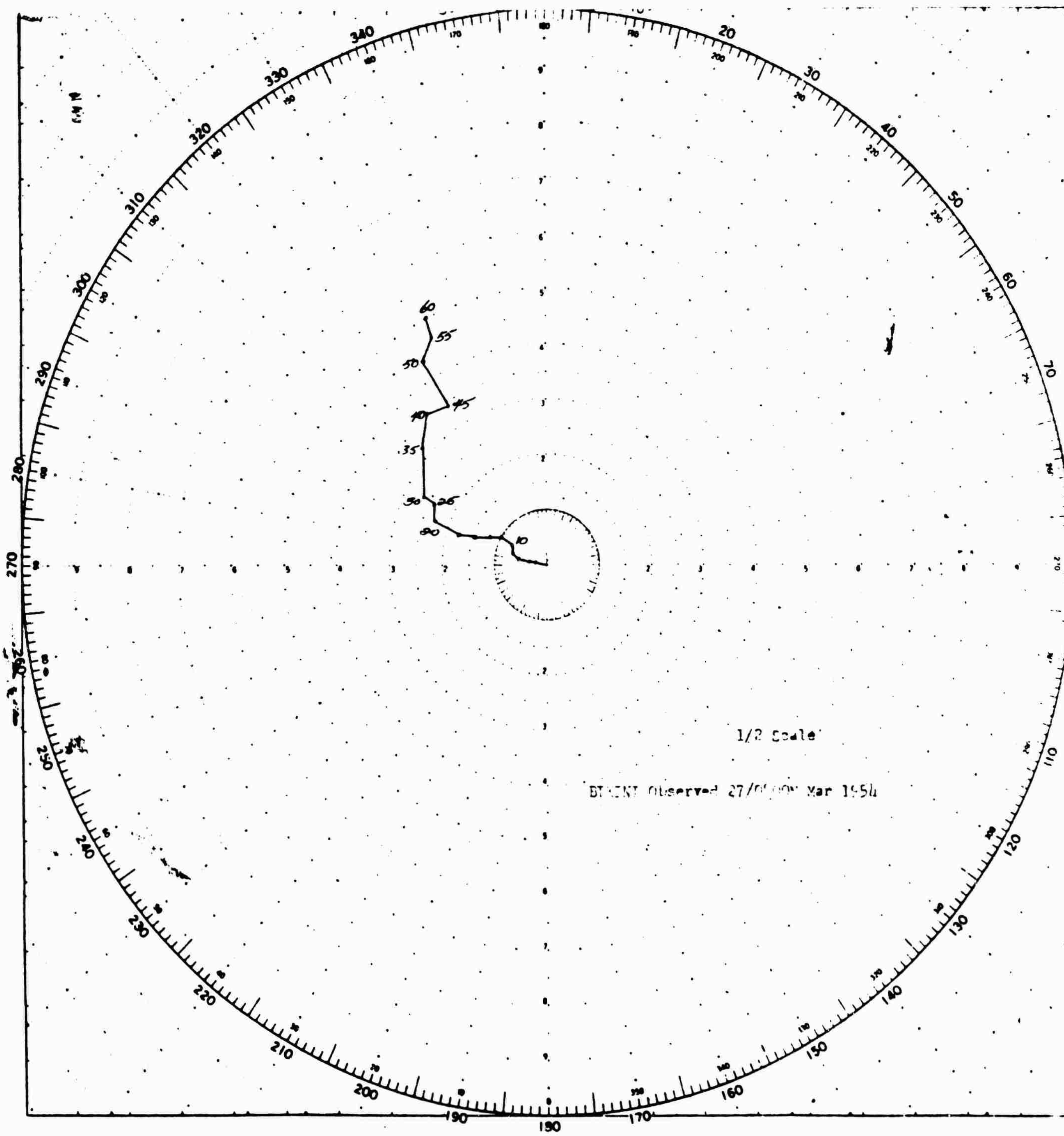
MADE 26/2200 M





1/2 Scale
BIKINI Observed 27/0000M Mar 1954


1/2 Scale
Observed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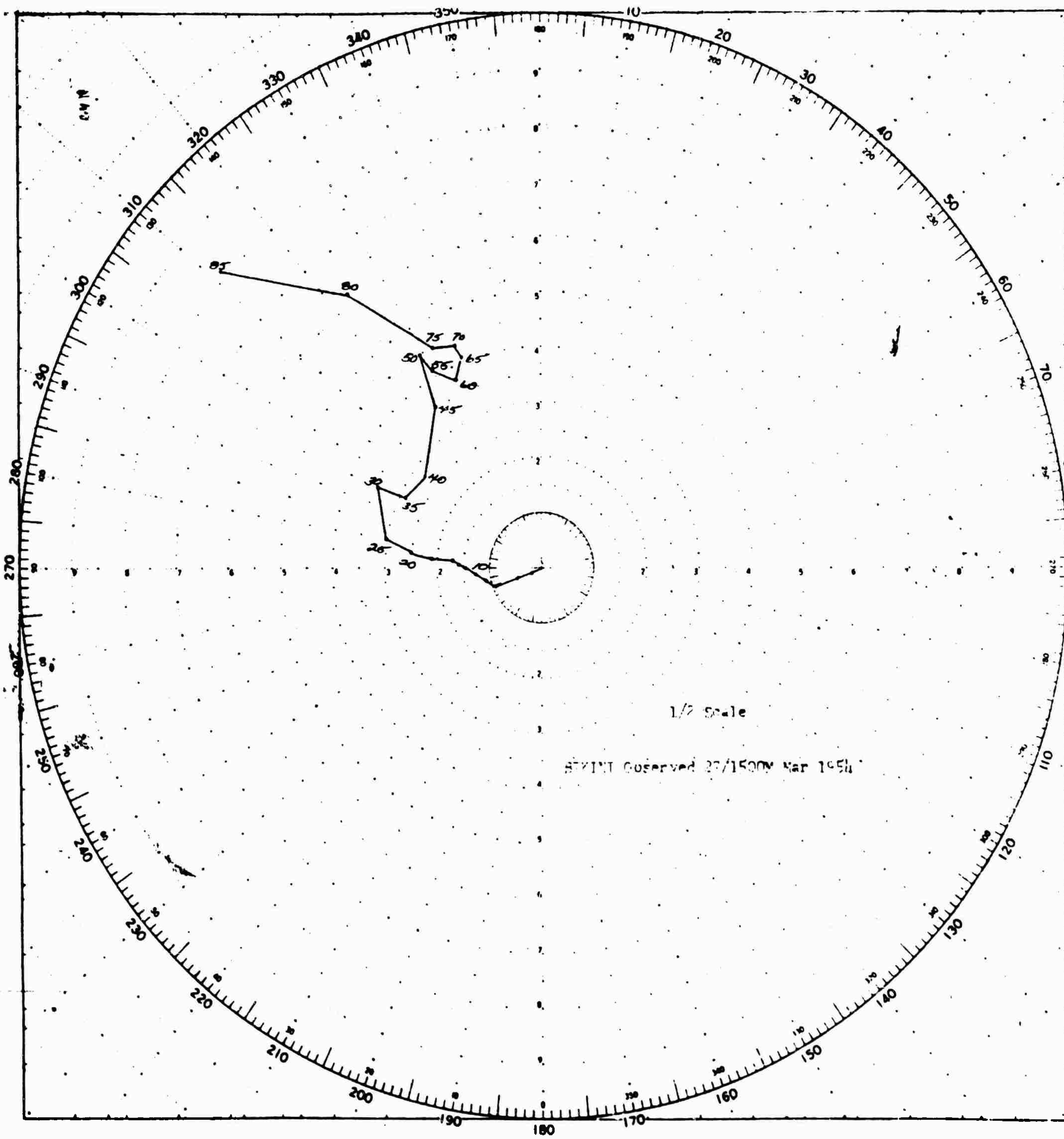
1/2 Scale
Observed
Mar 1954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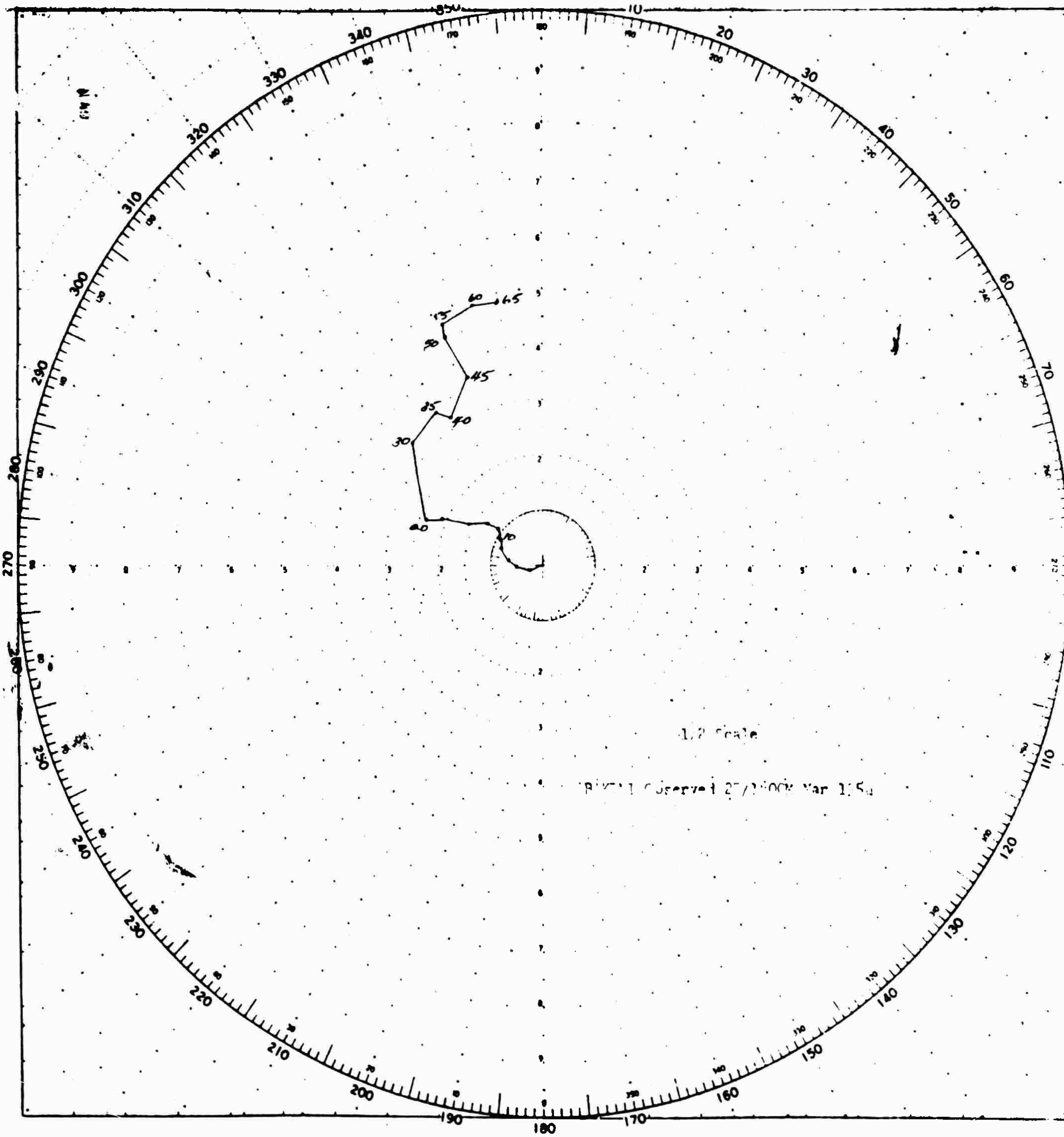
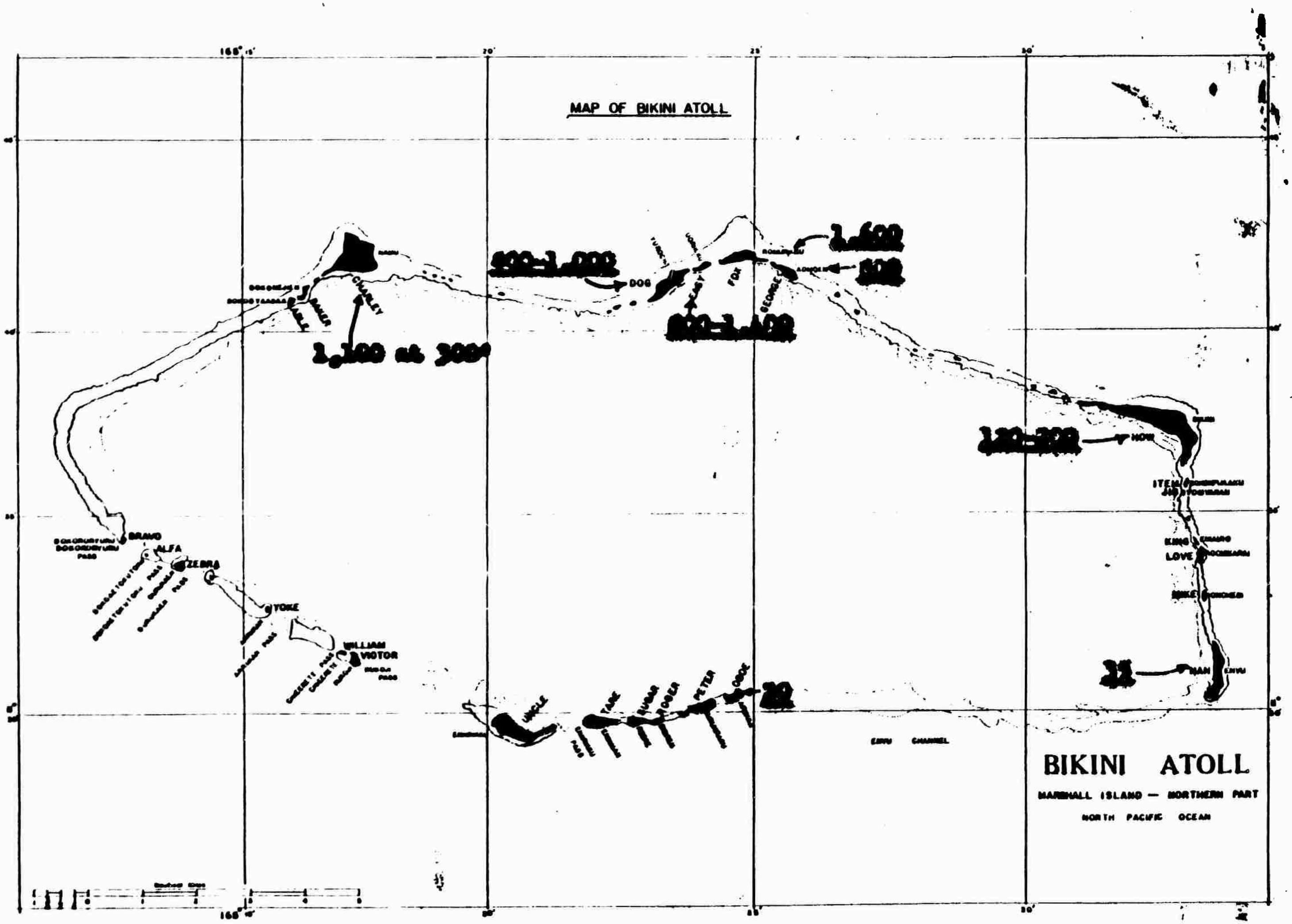
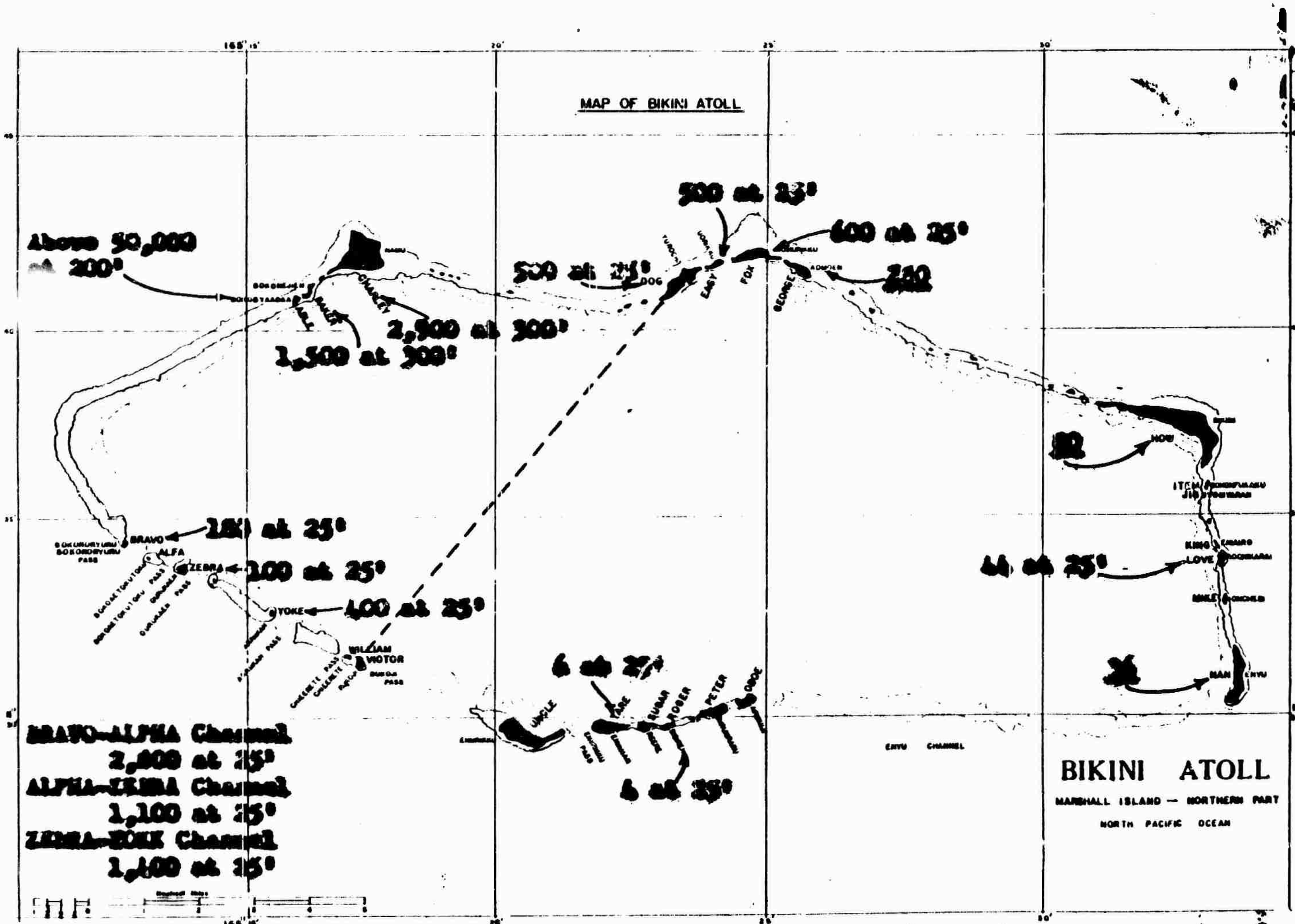
1/2 Scale
Observed



Scale
Observed



Radsafe Survey Readings BAKER Day (approximately H/4 hrs)
(All readings in mr/hr; ground readings underlined)



Radsafe Survey Readings ROMEO Plus One Day (H/30 hrs)
(All readings in mr/hr; ground readings underlined)
(Section of lagoon to the west of dotted line contaminated and flushing out western channels)

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AIR RADSAFE OPERATIONS FOR ROMEO

6 April 1954

1. SUMMARY: The Air Radsafe operations for ROMEO were successfully conducted and resulted in much timely information on post-event conditions. The ROMEO cloud reached an altitude on the order of 110,000 feet. In general it appeared that the lowest levels (surface to 6,000 feet) of the cloud moved to the southwest at a speed of approximately 10 knots. The next higher level (8,000 to 20,000 feet) moved to the west-northwest at about 12 knots. The upper levels and the stem moved out to the north. Outside the PPG all levels probably moved out to the east except the lowest levels which continued in a westerly direction. The cloud tracking operations yielded much timely and accurate information on these movements and proved that an evacuation of neither Eniwetok nor Ujelang was necessary. Both the sampling and the cloud tracking aircraft reports were used to good advantage to establish the reliability of a new technique for air radex preparation for high yield devices such as ROMEO. No hazardous radiation exposures were incurred by the personnel participating in the flight phases of the Air Radsafe Operations. There was no evidence of significant air contamination and subsequent fallout outside the enlarged Danger Area.

2. GENERAL:

a. Sources of Information: Cloud tracking information for ROMEO was, as for BRAVO, derived from five sources. The contribution of each of the sources (listed below) will be discussed in subsequent paragraphs.

- Sampling aircraft reports
- Sweet-Sour report
- Special Cloud Tracking Flights
- Weather Reconnaissance Flights
- AFOAT-1 Flights

b. Overall Cloud Movement (within the PPG): As will be seen from the shot time hodograph, wind shears existed at 8,000, 14,000, 25,000, 55,000 and 70,000 feet on ROMEO day. The winds at the lowest levels (Surface to 6,000 feet) were from the northeast at an average speed of 10 knots and carried very light particles from the base of the stem toward the southwest. This movement was verified by subsequent aircraft reports. The next higher levels of the stem (8,000 to 20,000) appeared to have moved to the west-northwest at an average speed of approximately 12 knots. This segment should have passed to the north of Eniwetok. Its early movement is clearly reflected by cloud tracking aircraft reports. The upper levels of the stem and the mushroom moved out to the north and the north-northeast (see Appendix I). It will be noted that the 55,000 and 60,000-foot levels are an exception to the northerly trend of cloud movement. These latter levels moved out generally to the north and then east. Fallout from these levels could have been carried back over Bikini and Eniwetok by subsequent "easterlies" at low levels. It is believed that this mechanism caused the fallout observed at Bikini approximately 36 hours after ROMEO and also that observed at Eniwetok roughly 12 hours later. This fallout was of little consequence other than as a "nuisance" factor (20-40 mr/hr at Bikini and 8-10 mr/hr at Eniwetok)

3. SAMPLING AIRCRAFT REPORTS: As before, these reports were monitored and recorded by Radsafe personnel aboard the Command Ship from plus two to plus seven hours. The reports from these aircraft were of considerable assistance in proving the validity of the assumptions used in preparing the pre-shot air radexes. Specifically reports from the planes, which worked the southern edge of the cloud, helped define the extent of initial cloud growth (and subsequent fallout) in a cross-wind direction. Further the late sampler's reports clearly indicated the extent of cloud dispersal which had occurred at plus six hours. At that time the sampler planes could find only a few small widely dispersed areas in which appreciable levels of radiation existed. The bulk of the sampling operations occurred between 35,000 and 40,000 feet just north of ground zero.

4. SWEET-SOUR REPORTS: These reports were submitted by any aircraft encountering radioactive contamination and not reporting by other means. One such report was received from an aircraft 55 NM, 157° from Eniwetok, altitude 1,500 feet, at 1550M. It is believed that this aircraft encountered light particles originating from the lowest levels of the stem. As has been pointed out above, this segment should have reached a point 100 miles southeast of Eniwetok at about plus ten hours. The exact radiation reading was reported as 33 mr/hr. It is of interest to note that the Control DDE in approximately the same area reported no surface contamination.

5. SPECIAL CLOUD TRACKING (WILSON) FLIGHTS:

a. A new technique was established for ROMEO to further enhance the effectiveness of the cloud tracking operations. This scheme placed a second WB-29 tracking aircraft in the holding pattern 50 miles west of ground zero. Each of these aircraft flew a racetrack course which was 75 miles long in a north-south direction and 25 miles wide. The length and position of this pattern is such that any cloud segments moving toward either Eniwetok or Ujelang should be intercepted by these aircraft. The planes were staggered in altitude. The lower altitude aircraft, Wilson 3, flew at 4,900 feet to avoid natural clouds and thus insured interception of cloud segments below the first wind shear level (6,000 to 8,000 feet). The second tracker held in the racetrack pattern at 10,000 feet for the purpose of monitoring cloud movements above the lowest shear level.

b. The first radiation contact reported by Wilson 3 at 4,900 feet was at 0903 Mike (ROMEO plus 2:48) at the south end of the racetrack (see Appendix I). The next report at 0933 Mike at the north end of the track was negative. Subsequent reports at the south end of the pattern at 0941, 1033, 1038 and 1057 Mike indicated contamination of between 50 and 100 mr/hr. This was undoubtedly the lowest level of the stem since it was encountered within minutes of the time which was forecast by the pre-shot air radex and hodograph. At 1219 Mike radiation levels of approximately 2 r/hr were reported at the north end of the pattern. It is believed that this was some of the same fallout encountered by Wilson 2 and which will be discussed below. One significant difference was noted, however, in that Wilson 3 reported the simultaneous collection of a "white, frost or snow" on the front of the aircraft. At this time the aircraft was ordered to the south end of the pattern to "cool off". The frost-like material was washed off in passing through a rain shower while responding to the above instructions.

The aircraft radiation background dropped markedly after passing through the shower. Subsequent readings in the pattern were background, so at approximately 1430 Mike, Wilson 3 was ordered to attempt to locate the southern edge of that portion of the cloud believed to be moving west-northwest. It was suggested that he proceed from the holding pattern to 12.5 north - 163 east and thence to Eniwetok. No contamination was reported on this phase of the flight which indicated that cloud movement was more northerly than had been presumed.

c. According to the pre-shot flight plan issued to Wilson 2 by Radsafe, this aircraft was to fly in the previously mentioned holding pattern from plus 2 to plus 5 hours. At the latter time he was then to proceed into an area search east of ground zero (limiting bearings 60 and 90 degrees true). The first contact with the cloud was reported by Wilson 2 at 1118 hours Mike at the north end of the racetrack pattern. The level was reported as being 850 mr/hr and must have been fallout from the southwesternmost edge of cloud segments which were moving north. It is significant to note that this aircraft never encountered any contamination at the southern end of the track although Wilson 3, 5,000 feet below him reported such material from approximately 0900 to 1100 Mike. This fact clearly establishes an upper limit of about 8,000 feet for cloud segments moving in a southwesterly direction and served as an excellent confirmation of both the air radex and the hodograph. Imm ediately after its initial cloud contact Wilson 2 proceeded east toward the previously designated search sector. At that time, however, Radsafe desired additional information concerning any possible cloud movement toward Eniwetok so Wilson 2 was ordered at 1200 Mike to return to the holding pattern. At 1215 Mike, Wilson 2 reported encountering cloud segments of approximately 2 r/hr at the northwest corner of the holding pattern. In order to evaluate the possibility of a hazard to Eniwetok and also to determine aircraft background this aircraft was also ordered by Radsafe to proceed to "hold" in the south end of the pattern. Subsequent reports showed no cloud moving toward Eniwetok and aircraft background of 240 mr/hr. At 1430 the aircraft was directed to proceed with the originally specified area search east of Bikini. Subsequent search out to 13.5 north - 171.5 east (100 miles west of Bikar) and thence to base resulted in reports of no radiation above aircraft background. The crew exposure on Wilson 2 and 3 was of the order of 1.4 r.

d. Wilson 4 was directed to proceed at 10,000 feet from base to a sector bearing 60 to 90 degrees from ground zero at plus 12 hours and search out to 500 NM. From this sector the return to base was via a point 16 north —162 east. The flight was performed as ordered, but all reports were negative throughout.

e. Subsequent Wilson flights (for plus one day) were cancelled when it appeared that no appreciable air contaimination existed at that time in the vicinity of the test site.

6. <u>WEATHER RECONNAISSANCE FLIGHTS</u>: Two Petrel Juliet weather reconnaissance flights were flown on plus one day. These flights were flown to approximately 800 NM to the south of Eniwetok and indicated essentially zero air contamination.

7. AFOAT-1 FLIGHTS: AFOAT-1 sponsored flights from Hawaii made radioactive sample collections at 0100 Mike, 31 March (plus 91 hours) at 19,000 feet, 150 nautical miles southwest of Johnston Island. It is estimated that these levels were 0.010 mr/hr. Similar flights from Guam made collections approximately 350 miles southeast of that base. The first such collection was at 2,000 feet at 2200 hours Mike on 30 March (plus 88 hours) where the radiation levels were approximately 0.001 mr/hr. This time agrees well with the rate of movement of the 10,000-foot levels of the cloud. The second collection was made 19 hours later at 25,000 feet with radiation levels of approximately 0.015 mr/hr.

8. INFLIGHT EXPOSURES: All inflight radiation exposures appeared to be well within Task Force limitations.

9. AIR RADEX: The ROMEO pre-shot air radex is attached as Appendix II. This radex was prepared using standard radex procedures with two changes incorporated to adapt the method to devices of megaton yields. Subsequent ROMEO cloud tracking data confirmed, with surprising accuracy, the validity of these techniques. The procedure used is as follows. The conventional radex preparation procedures (see Air Weather Service Manual 105-33) were used to obtain the area of contamination at 1 hour for each of the two levels for which a radex was desired (10,000 and 40,000 feet). The areas so obtained are based on what is essentially a point source (at each altitude). While such an assumption is valid for KT yield devices, it gives dangerously misleading results for devices with megaton yields. This is due to the fact that the stem and mushroom grow within minutes to lateral dimensions which are large as compared with the wind speeds. This mechanism vastly increases the area of fallout and accounts for the presence of contamination often encountered at considerable distances in up-wind or cross-wind directions. To forecast the extent of these areas at 10,000 feet a circle having a radius of 2.5 NM was drawn about ground zero. Then the zero point of the contaminated area was placed on this circle. While maintaining the directional orientation of the radex an area was generated by moving the zero point around the circumference of the circle (see sketch).

CLASSICAL RADEX

RADEX FOR HIGH YIELD DEVICES

The area swept out by this process was used as the contaminated area for the high yield device. The same process was used for the 40,000-foot level except that the radius of the circle used was the radius of the mushroom minus one-half the wind speed at 40,000 feet. For ROMEO the radius of the circle used was 25 miles. The validity of this scheme was clearly demonstrated by the fact that the radex so constructed accurately forecast the sampling area and the movement of contamination across the racetrack pattern of the Wilson aircraft.

10. CONCLUSIONS:

a. The Air Radsafe Operations for ROMEO were quite successful, primarily due to the changes incorporated since BRAVO.

b. The cloud tracking operations established the excellent correlation between the forecast air radex, the hodographs and the observed post-event conditions.

c. The cloud tracking operations yielded timely and reliable information early establishing the fact that there were no elements of the ROMEO cloud which necessitated evacuation of Eniwetok or Ujelang Atolls.

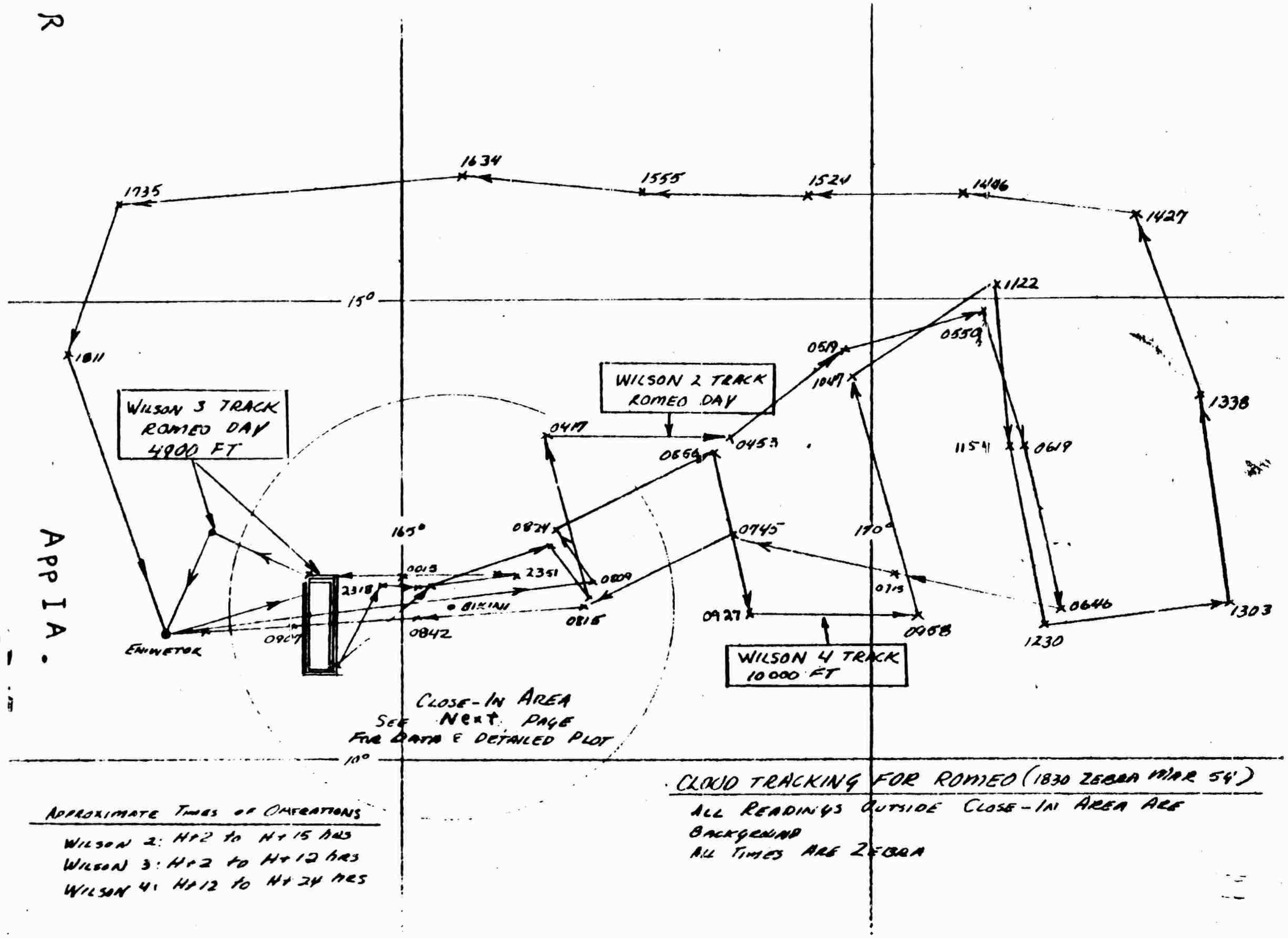
d. No hazardous fallout appeared likely in the Guam, Ponape or Hawaii areas as a result of ROMEO.

e. The new techniques for drawing the air radex for high yield devices was quite reliable.

11. RECOMMENDATIONS: A critique should be held with the Wilson aircraft crews to work out the few minor data reporting problems which arose during ROMEO (This was accomplished on 31 March.).

2 Appendices
I. Wilson A/C plot (A&B)
II. Air Radex

R



CLOUD TRACKING FOR ROMEO (1830 ZEBRA MAR 54')

ALL READINGS OUTSIDE CLOSE-IN AREA ARE BACKGROUND

ALL TIMES ARE ZEBRA

APPROXIMATE TIMES OF OPERATIONS

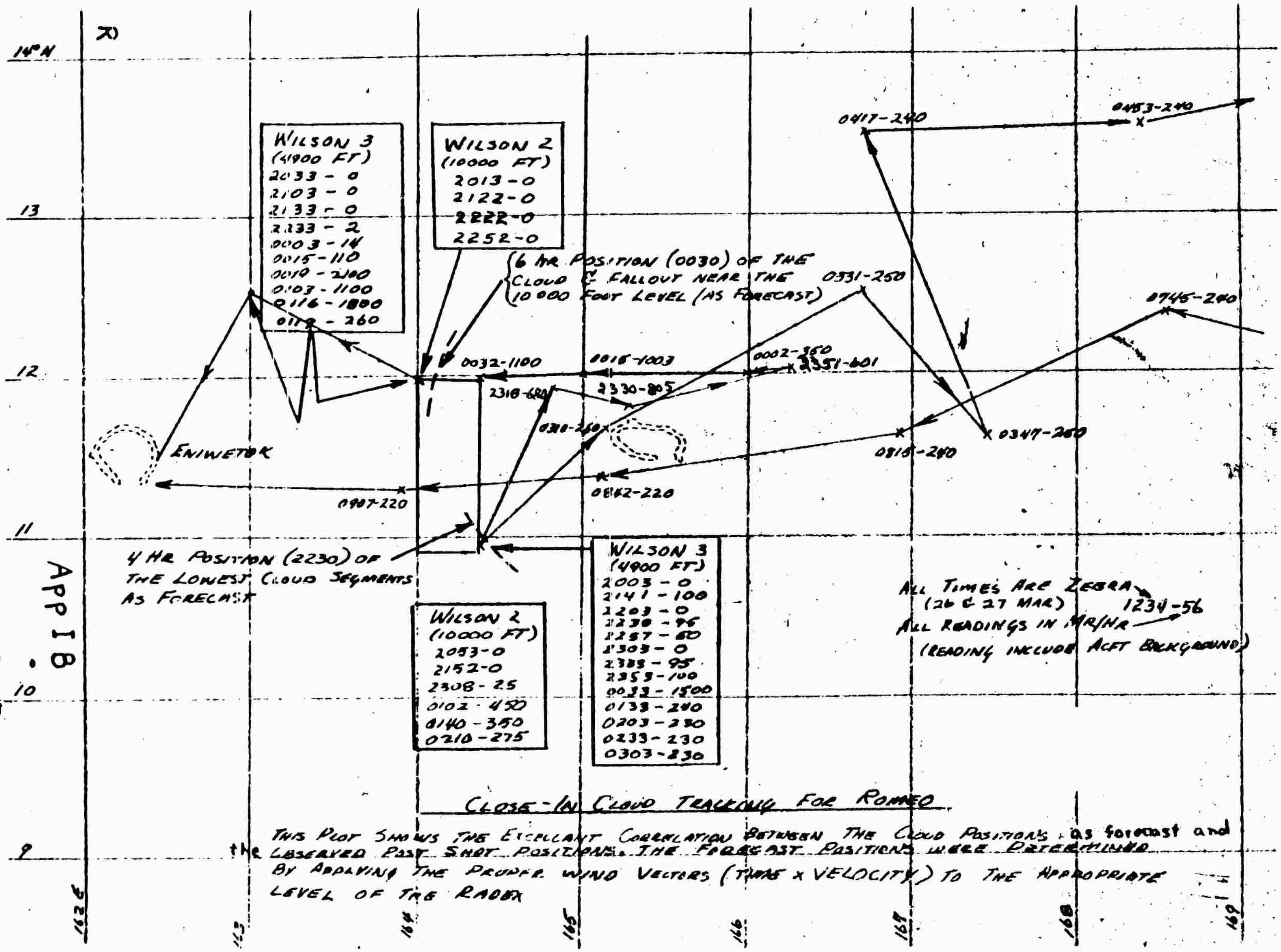
WILSON 2: H+2 to H+15 HRS

WILSON 3: H+2 to H+12 HRS

WILSON 4: H+12 to H+24 HRS

App IA.

L-40a



CLOSE-IN CLOUD TRACKING FOR ROMEO

THIS PLOT SHOWS THE EXCELLANT CORRELATION BETWEEN THE CLOUD POSITIONS as forecast and the OBSERVED POST SHOT POSITIONS. THE FORECAST POSITIONS WERE DETERMINED BY APPLYING THE PROPER WIND VECTORS (TIME x VELOCITY) TO THE APPROPRIATE LEVEL OF THE RADEX

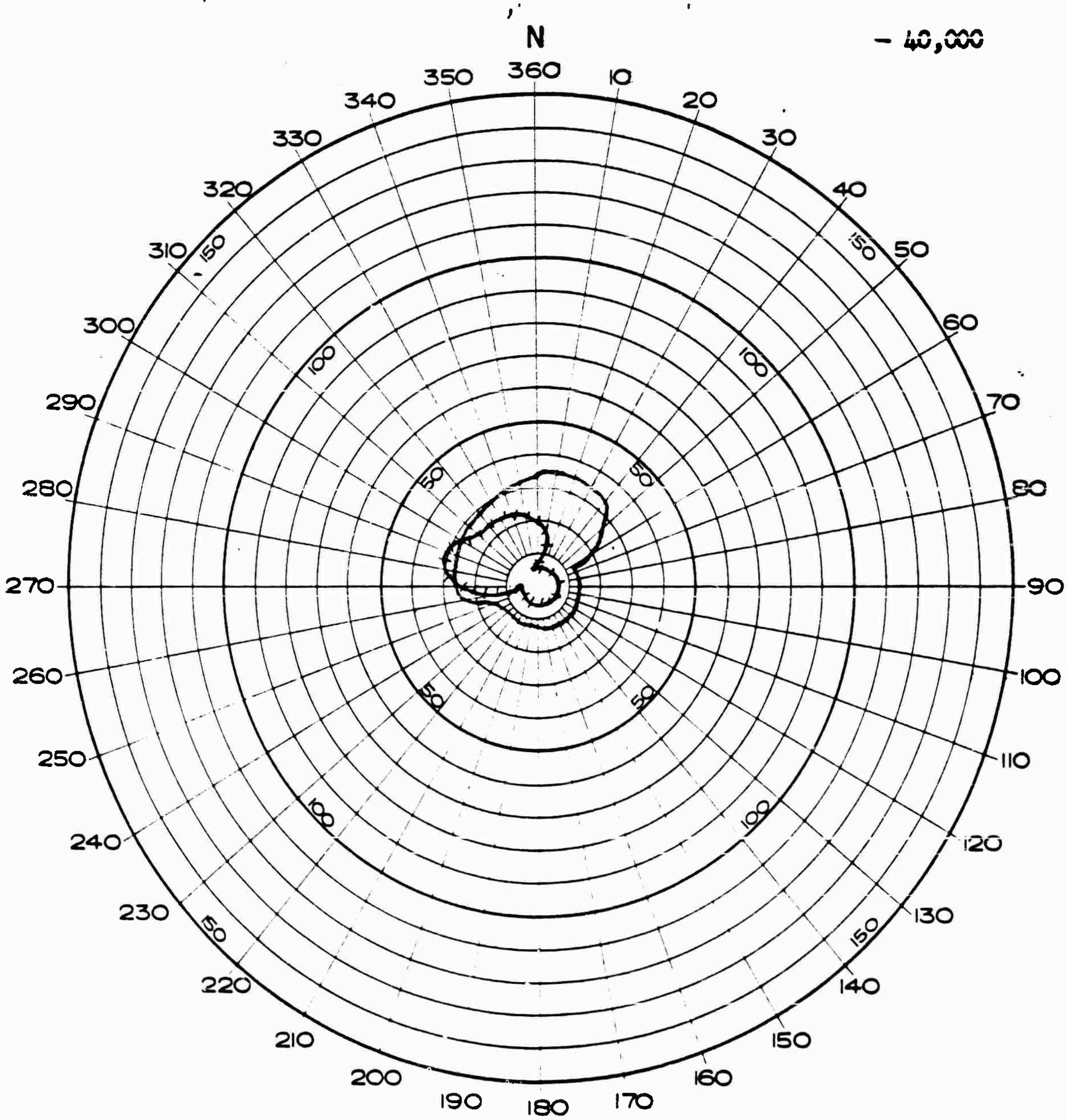
App I B

HODOGRAPH

RESULTANT WINDS AND SURFACE RADEX

+ 10,000

— 40,000



ROMEO AIR RADEX FOR ROMEO PLUS ONE HOUR

L-40c

PRELIMINARY RESULTS

NYKOPO Airborne Monitoring Survey Flights o/a 27 March 1954
(Conducted by Health and Safety Laboratory, New York Operations Office, AEC)

Location (Atoll unless otherwise indicated)	Local Time (March)	Maximum Ground Reading (mr/hr)	Local Time (March)	Maximum Ground Reading (mr/hr)	Local Time (March)	Maximum Ground Reading* (mr/hr)
ABLE						
Kwajalein	191200	00.10	280704	00.00	311435	00.20
Lae	191602	00.012	280747	00.00	310832	00.08
Ujae	191615	00.06	280754	00.00	310840	00.24
Wotho	191643	00.05	280829	00.00	310910	01.70
Ailinginae (Sifo Is.)	191710	20.00	281123	06.00	311005	26.00
Rongelap Island	191720	15.00	281134	28.00	311022	78.00
Rongerik Island	191739	80.00	281153	36.00	311036	58.00
Taongi	—	—	281315	01.00	311158	00.40
Bikar	191848	28.00	281415	00.08	311257	15.00
Utirik Island	191910	12.00	281438	00.00	311320	06.80
Taka	—	—	281448	00.80	311330	06.80
Ailuk	191938	01.00	281503	01.60	311345	02.40
Jemo	191951	00.02	281518	00.80	311400	02.40
Likiep	—	—	281525	00.40	311407	01.00

*Ground Observation.

BAKER	(April)	
Namu	030834	00.40
Ailinglapalap	030857	00.55
Namorik	030933	00.70
Ebon	030959	01.10
Kili	031004	00.90
Jaluit	031035	01.40
Mili	031125	00.70
Arno	031146	00.90
Majuro	031153	00.90
Aur	031209	00.90
Maloelap	031230	00.50
Erikub	031253	00.90
Wotje	031304	01.40
Kwajalein	031354	01.40

Maximum Ground Readings
Other NYKOPO Flights
(in mr/hr)

Flight DOG (1 April)	00.00
Flight FOX (3 April)	00.00

SUMMARY OF THE STATUS OF TRANSIENT SHIPPING IN THE PACIFIC PROVING GROUND AREA ON OR ABOUT 27 MARCH 1954

1. Task Force sources of information:

a. PC 1172, Kwajalein at 270600M.

b. LST 1157, 10-45N, 170-14E, course 270, SOA 9.5 knots.

c. LSIL 9035 and LSIL 9039 (French vessels) 19-31N, 168-42E, course 270, SOA 10 knots.

d. Fishing vessel last reported 7-30N, 168-00E, course 330. (No further contacts in Area Green and sector searches.).

e. KAIKO MARU departed Wake 221545M. Estimated 262000M position 10N, 174E; destination 10N, 175E.

f. MALIKA (British vessel) requested by ComNavFor Marianas at 221900M to stay clear of enlarged Danger Area.

g. DAI MARU departed Wake for Japan 220130M via route point 20N, 165E.

h. USS GENESSEE, 14-10N, 179-39W at 271200M. ETA Pearl 302200Z, course 82.

i. Visual/Radar search aircraft contact: One Japanese fishing boat, No. KN2482, 15-02N, 167-53E, course 115, SOA 10 knots at approximately 221300M. Patrol plane diverted vessel to course 90; no further contact made of this boat.

j. Visual/Radar search aircraft contact at 211130M, one fishing boat, 19-45N, 161-18E, course 120, SOA 10 knots, nationality doubtful. Upon direction, search aircraft turned stranger to the northeast at 1230M. No further contacts made of this boat.

k. M/V GUNNERS KNOT, 270600M, position 7-10N, 168E, course 270, SOA 10 knots.

l. M/V ROGUE, 270600M position Kwajalein.

Incl 8

TAB "M"

KOON EVENT

"TAB M"

KOON

The first attempt to fire KOON was 6 April. This headquarters and task group staffs deployed to Bikini on 5 April and set in motion the entire sequence of pre-shot events. Area GREEN was searched on 5 April plus a sector search 240 NM wide to 600 NM centered on 30° true from GZ. Complete advisories were issued to the British Sampling Unit on Kwajalein and to CINCPACFLT. Forecast surface and air RADEXES were issued to all task force units. The series of briefings continued until midnight; ultimately resulting in a postponement of the shot for 24 hours.

PC 1546 had been ordered to Rongerik to serve as floating housing for the weather detachment and Project 6.6. Arrangements had been made for the Officer-in-charge, Wake Island Weather Bureau Station to assume radsafe monitor responsibility for Wake and to make special reports to the task force headquarters if and when intensities passed through 10, 50, 100 and 500 mr/hr and as required by circumstances above 500 mr/hr. Radiac instruments were supplied to the Wake station by TG 7.4. In accordance with operational requirements the task force fleet was positioned in a sector from 90° to approximately 120° from GZ, minimum distance 26 NM.

By morning of 6 April the synoptic weather situation was such as to forecast favorable shot conditions for the following day. At approximately 1400M, 6 April, the forecast surface and air RADEXES were issued as follows:

Surface RADEX: True bearings from GZ 240° clockwise to 70° radial distance 90 NM for H to H plus 6 hours plus a circular RADEX around GZ of 15 NM. A recommendation was included with the surface RADEX to move the Control DDE to 240° and 90 NM from GZ, and to move the task force ships to a southeast position from GZ as soon as possible post-shot.

Air RADEX: H plus 1, 10,000 feet and up (true bearings from GZ):

240° clockwise to 20° maximum distance 20 NM
20° clockwise to 85° maximum distance 30 NM

40,000 feet and up (true bearings from GZ):

240° clockwise to 10° maximum distance 25 NM
10° clockwise to 95° maximum distance 45 NM

For H plus 6 hours multiply above distances by six. Due to initial cloud growth, supplement the 10,000 foot RADEX for H plus 1 hour with sector bearing 85° True, clockwise to 240° True, maximum distance 5 NM. Supplement the 40,000 foot RADEX for H plus 1 hour with sector bearing 95° True, clockwise to 240° True, maximum distance 15 NM.

At about the same time, the routine H minus 18 hour advisory was dispatched to CINCPACFLT announcing KOON schedule for 070620M, weather permitting. The advisory included the forecast 72-hour air particle trajectories for ten, thirty, fifty and sixty thousand feet. A statement was included to the effect that no significant fall-out was forecast for populated Marshall Atolls. It was recommended that no air routes be closed. No health hazard problem was forecast for surface routes outside Area GREEN. CINCPACFLT was advised that an intensive search was being conducted in Area GREEN and in a sector 240 NM wide out to 600 NM centered on true bearings 45° from GZ. As an additional safety measure CINCPACFLT was requested to divert all ships from the sector Danger Area 240° clockwise to 95° to 450 NM. No known transient ships were in the area. (Note: The sector search on 45° was subsequently cancelled due to a similar search on 30° the previous day. It was decided that the sector search would be conducted post-shot if necessary. Due to the low yield, this requirement did not materialize.)

The British Sampling Unit on Kwajalein was notified of the current scheduled shot date, and informed that further information would be included in the H minus 6 hour advisory.

At the midnight Command Briefing, the forecast shot time winds were favorable, having considerable southerly flow in the mid-levels. However, light to moderate scattered showers were forecast for H-Hour and beyond. It was decided to stand firm on the decision to shoot and to take a look at the weather/radsafe situation again at 0430 on shot day. The forecast fall-out plot by elliptical approximation is included in Inclosure 4.

At approximately 2200M CTG 7.4 was directed to set up the first two cloud trackers, Wilson 2 and Wilson 3. Wilson 2 was directed to search from H plus 2 to H plus 14 hours from base to a three-hour racetrack holding pattern 50 NM west of GZ at 10,000 feet, thence to a 500 NM sector with limiting true bearings from GZ of 65° and 95° at 10,000 feet. Wilson 3 was directed to search from H plus 2 hours until released, in the holding pattern specified above, at an altitude selected by the pilot to clear natural clouds, but not in excess of 6,000 feet. (Wilson 3 ultimately flew at 4,900 feet.)

Based on the recommendations contained in the Surface RADEX directive, CTG 7.3 informed all task groups of the following ship movements for shot time: the H-Hour position of the Command Ship (ESTES) would be on true bearing from GZ of 88° at 25 NM. At H plus 5 minutes, (i.e., after completion of firing requirements) the Command ships would commence moving south at 15 knots. Its probable H plus 2 hour position and thereafter would be 134° True, 33 NM all from GZ with a possibility of moving from that position at approximately H plus 3 hours if the situation permitted. The Flagship of CTG 7.3 (CURTISS) would initially be on true bearing 120°, 25 NM all from GZ, then move south approximately 15 NM after H plus 10 minutes (i.e., after completion of Raydist requirements.) All other ships except the destroyers would move south with the CURTISS post-shot, and maintain shot-time spacing and dispositions relative to her. The Control DDE would be at 240° True at 90 NM all from GZ.

At midnight 6 April a directive was issued to run NYKOPO Flight Able on KOON day, the survey aircraft to take-off approximately 071500M, by-pass Bikini, avoid contaminated areas, make in-flight reports of data and to continue the Able pattern at least to Taka if practicable.

At approximately H minus 6 hours, the British Unit on Kwajalein was advised of the forecast 72-hour air particle trajectories and the forecast GZ H-Hour winds. Authority was included for the British Unit to penetrate the Danger Area in accordance with scramble and routing instructions to be issued by CTG 7.4 post-shot. By a previous advisory continued for 7 April, the British Unit had been directed to file flight plans through the Kwajalein Liaison Officer using the task force advisory as authority for KOON flights.

A final weather radsafe check was made at 0430M with no significant change made in the original forecast. The final observed GZ wind check at approximately 0530M was favorable; however, at shot time there was a large rain shower between the fleet and GZ, possibly extending to GZ itself. Cloud cover extended up to 40,000 feet, with a broken base at 2,000 feet. Transient shipping contacts being favorable, KOON was detonated on the surface of the western tip of Eniman Island at 070620M April 1954 without undue incident to the embarked task force personnel and ships. Post-shot advisories were issued prior to H plus 30 minutes to the Chairman AEC, C/S Army and CINCPACFLT as on past shots, indicating time of detonation and a general statement of safety of personnel. Due to the low yield of the task force fleet to the south was cancelled at 0630M.

Based on a preliminary damage and radsafe survey made by helicopter at approximately H plus 2 hours, all units of the task force were issued an advisory directive as follows: SUGAR through OBOE and NAN not appreciably contaminated; R-hour expected to be 071100M; CTG 7.3 have task force vessels stand off the lagoon entrance at 1000M pending the outcome of the lagoon water survey of the TARE and NAN anchorages; upon confirmation of R-hour, all units re-enter NAN anchorages in accordance with previous instructions.

During the early morning hours the two cloud trackers (Wilson 2 and Wilson 3) made no contact with the cloud except one reading by Wilson 3 of 15 mr/hr west of Bikini. Following the holding pattern search Wilson 2 advanced at H plus 5 hours to its upwind sector. Wilson 3 was directed at 1220M to search a 30° sector centered on 45° True from GZ to maximum range at 9,000 feet.

By 1000M an additional advisory directive was issued to all units confirming R-hour. This dispatch stated that cloud tracking and other operational flights since H-Hour indicated no radiation hazard to surface operations or to flight operations at any altitude south of Bikini. It advised that the preliminary lagoon water sampling indicated NAN anchorages below safe radiation limits. Further, it included the Radsafe survey in mr/hr contamination as follows: SUGAR 45 maximum, air strip 15, UNCLE 25,000 at 300 feet, TARE anchorages 3,000 at 25 feet, NAN 25. R-hour was announced for 1000M, and that effective at R-hour, recovery operations would be controlled by the Radsafe CENTER of TG 7.1. Water and air traffic in the vicinity of NAN anchorages and to the air strip was declared radsafe unrestricted provided no landings were made on islands other than OBOE. All other water and air traffic was declared subject to clearance by the Radsafe CENTER. Swimming in the lagoon was prohibited until further notice. At R-hour, all units were directed to commence re-entry to NAN anchorages in accordance with previous plans.

Due to the low yield and the favorable observed shot day winds, NYKOPO Flight Able for KOON day was postponed to K plus 1 day.

Throughout the shot day, cloud tracking was routine and in accordance with plans. The few, low intensity, contacts made with the cloud did, however, fit the forecast fall-out pattern. As a consequence, all Wilson flights after Wilson 3 were considered unnecessary and CTG 7.4 was notified accordingly.

Due to the high contamination in the vicinity of GZ (in the lagoon as well as on land), the southwestern portion of the lagoon rapidly concentrated high intensities over the water and in the slowly flushing channels to the southwest. Specifically, Eniriiku Pass (off the west end of TARE) was particularly prominent with a slowly flushing, high intensity, milky residue. As a consequence, CTG 7.3 denied use of this channel to all ships until further notice.

Based on the Wilson holding pattern flights, no fall-out was anticipated at Eniwetok or Ujelang. This was verified at approximately 1900M on shot day through a report received from the radsafe monitoring systems at Eniwetok to the effect that FRED, ELMER and URSULA were reading background.

In accordance with plan, the first (and final) 2000M post-shot advisory was dispatched to CINCPACFLT. CINCPACFLT was informed that further advisories would be contingent on further circumstances. The advisory stated that due to the unexpected low yield, no significant radsafe problems were anticipated. No change was made in the forecast 72-hour cloud trajectories as given in the H minus 18 hour advisory, and a statement was included that no health hazards were existent or forecast for surface or air routes. The advisory further stated that no significant fall-out was existent or forecast for populated atolls, but that NYKOPO Flight Able had been scheduled for K plus 1 day. CINCPACFLT was informed that any KOON readings in excess of 10 mr/hr would be forwarded.

On 9 April CINCPACFLT was informed that the following apparent increases in radiation intensities were experienced in the Marshall Islands as a result of KOON: (In mr/hr on 8 April) - Ailinginae 47, Rongelap 62, Rongerik 51, Bikar 16, Utirik 10, and Taka 11. CINCPACFLT was advised that no special action was required.

On 12 April, information received from CTG 7.3 relative to ship contamination was passed to CINCPACFLT in accordance with a post-BRAVO request by CINCPACFLT for such information. This advisory indicated that no significant fall-out was reported on any ships, that although a small part of the lagoon in the vicinity of shot sites was highly contaminated, it was not expected to become a problem to ships.

On 12 April, in accordance with lagoon water sampling, and in the interest of morale of the Bikini garrison, swimming was permitted on the lagoon side of the north end of NAN.

Since the activities of the AEC New York Operations Office had a considerable impact on task force post-shot off-site radsafe operations, the final report of this agency is suggested as additional information on the long-range aspects of KOON.

7 Incls:
1. An Evaluation of Weather Forecasts for KOON.
2. Tabulation of KOON Pre-shot and Post-shot Winds from Task Force Stations.
3. Forecast and Computed KOON 72-hour Air Particle Trajectories.
4. KOON Ground Zero Hodographs.
5. KOON Shot Day Ground Radiation Intensities On-Site.
6. Air Radsafe Operations for KOON.
7. Preliminary Results, NYKOPO Airborne Monitoring Survey Flights, on/about 7 April 1954.
8. Summary of the Status of Transient Shipping in the PPG Area o/a 7 April 1954.

AN EVALUATION OF WEATHER FORECASTS FOR KOON

1. Summary of weather immediately prior to K-Day: On 31 March a forecast was issued for 2 April that indicated southerly winds for levels 20,000 through 50,000 feet. This admittedly was a long range forecast with only fair confidence. Twenty-four hours later, however, it was evident that no foreseeable development of the circulation aloft would give appreciable southerly components to the winds aloft. A deep trough dominated upper level flow between Johnston and the Marshalls giving persistent winds with northerly components. On the morning of 4 April, the trough showed a tendency to fill, and a weak outdraft began to form east of Majuro. The development was slow; only at 40,000 feet was it consistent and progressively more pronounced. On the morning of 4 April a forecast based on the development of the outdraft was issued. By afternoon of the 4th a firm trend had not been established and a forecast giving winds of a northerly component was issued. After this vacillation over a three day period the trend for the development of the outdraft near Majuro became firmly established on the morning of 5 April. The outlook was issued that chances were good for southerly winds on 6 April, and if not that day, certainly on the following day.

2. The Weather Forecast: 3/8 cumulus, base 2000; 2/8 altostratus, base 20,000 feet; 6/8 cirrus, base 39,000 feet; scattered light and moderate showers; increased buildups in cirrus to south of area; shower activity greater in Eniwetok area.

a. Observed weather: 3/8 cumulus, 3/8 stratocumulus, 2/8 altocumulus at 15,000 feet; scattered rain showers reported at Eniwetok.

b. Comments on weather: Wilson 1 (reconnaissance aircraft near shot site) reported 2/8 cumulus and 8/8ths altostratus at 16,000 feet one hour prior to shot time. At Eniwetok the cumulus layer increased to become broken from 1400M to 1800M following the shot.

3. The Wind Forecast:

HEIGHT (Thsds Ft)	H-24	H-15	H-8	H-4	OBSERVED BIKINI 0900M
90	090/40	090/45	090/40	090/40	
80	090/30	090/30	090/30	090/30	
70	090/20	090/15	100/20	100/20	150/35
65		120/10	120/15	120/15	130/15
60	070/10	180/12	230/15	230/15	290/13
55	270/10	230/15	240/20	240/20	250/18
50	250/25	270/30	250/20	270/30	260/32
45	240/25	240/30	230/35	240/35	260/37
40	230/25	230/25	230/30	230/35	250/33
35	230/20	240/30	230/28	230/28	240/24
30	240/15	260/20	230/20	230/20	250/21
25	240/15	250/15	260/14	230/10	200/20

HEIGHT (Thsds Ft)	H-24	H-15	H-8	H-4	OBSERVED BIKINI 0900M
20	240/17	240/04	350/05	230/10	210/16
15	180/05	170/06	Lt&Var	180/05	170/15
10	100/12	120/10	140/15	160/15	170/12
08	080/12	120/10	140/17	140/15	160/12
06	070/15	110/15	150/16	100/15	150/09
04	080/15	100/15	150/12	080/15	090/12
02	070/15	100/15	110/10	080/14	080/20
SFC	060/12	090/15	090/10	060/12	070/17

a. Comment on winds:

(1) 50% of the forecast wind directions were within 10 degrees of the observed; 78% were within 20 degrees. The greatest deviation was 60 degrees at 60,000 feet, immediately above the tropopause.

(2) 61% of the forecast wind speed deviated 4 knots or less from the observed, and 89% deviated 10 knots or less. The maximum error was 15 knots at 70,000 feet.

KOON

Date 7 April 1954 Time 0620 L Local Observation Time 0620 L

Clouds lower 2/8 Cumulus Base 2,000 Tops 8,000 Middle Alto Cumulus Base 18,000

Isolated ~~Tops of~~ Cu 30 To 40 M Visibility 15 Miles

Sea Level Pressure 1009.7 Mb Wind direction 090 degrees Velocity 13 Kts

Surface temp 81 °F Dew Point 75 °F Humidity 82 % Vapor pressure .888

Local weather Showers Remarks (Tops all clouds reported by aircraft 40,000)

Latest winds aloft taken on Curtiss Position Bikini Time 0400M

ALTITUDE	DEGREES	KNOTS	PRESSURE	TEMP	DEW POINT	R H
Surface	040	20	1009.7	81 °C	75 °C	79 F
1,000 Ft	070	17	973	23.5	22.0	
1,500			958	22.4	21.2	
2,000	060	16	940	21.1	20.4	82
3,000	090	08	909	19.7	19.0	
4,000	120	07	878	18.4	17.5	80
5,000	150	08	848	17.1	16.2	
6,000	170	12	819	15.8	14.9	78
7,000	170	17	789	14.3	13.5	
8,000	190	14	760	12.7	12.2	
9,000	200	14	733	11.2	10.9	
10,000	210	14	705	9.8	9.5	75
12,000	180	17	655	6.5	5.6	
14,000	200	08	608	3.0	-0.9	69
16,000	190	10	563	-0.3	-10.4	67
18,000	200	10	522	-3.8	-12.9	64
20,000	220	04	483	-7.8	-23.6	24
25,000	190	20	396	-18.0	-29.6	24
30,000	210	22	322	-27.5	-32.9	42
35,000	210	28	258	-39.8		
40,000	230	34	206	-51.8		
45,000	280	24	161	-63.8		
50,000	240	35				
52,000	230	39				
60,000						
65,000						
70,000						
75,000						
80,000						
85,000						
90,000						
95,000						
100,000						
105,000						
110,000						
115,000						
120,000						
125,000						
130,000						
135,000						
140,000						
145,000						
150,000						

REMARKS:

M-8

BIKINI-KOON SHOT. 0630M. 7 APRIL 1954

LEVEL	H-8 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0613	0915	0420	0717	0813
2000	0815	0714	0616	0820	0815
4000	0913	1108	1207	0912	1019
6000	1111	1706	1712	1509	0815
8000	1613	1909	1914	1612	1013
10000	1716	1914	2014	1712	1406
12000	1404	2020	1817	1613	1510
14000	1306	1118	2008	1709	1810
16000	1410	2224	1910	1715	1807
18000	1313	2208	2010	1819	2803
20000	2108	2506	2204	2116	2610
25000	2508	2008	1920	2020	2116
30000	2315	1925	2122	2521	2231
35000	2430	2425	2128	2424	2231
40000	2340	2547	2334	2533	2548
45000	2432	2329	2824	2637	2444
50000	2731	2531	2435	2632	2541
55000	2430		2339	2518	2629
60000				2913	2406
65000				1815	1623
70000				1535	1123
75000					0825
80000					0923

ENIWETOK-KOON SHOT, 0630M, 7 APRIL 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0613	0612	0610	1116	0610
2000	0714	0714	0813	1314	1216
4000	0707	0909	0912	1309	1512
6000	0908	0705	0909	1105	1409
8000	0911	0805	0908	1107	1409
10000	1010	1309	0905	1507	1410
12000	1412	1609	1307	1607	1805
14000	1212	1709	1808	1608	1804
16000	1010	1708	1706	1705	3307
18000	0917	1706	1703	2703	3310
20000	0511	1606	2104	2708	3212
25000	0208	2406	2414	2322	2220
30000	2025	1926	2022	2120	2128
35000	Missing	2325	2422	2527	2435
40000	2334	2434	2435	2335	2441
45000	2637	2737	2543	2425	2540
50000	2627	2640	2530	2428	2541
55000	2626		2535	2905	2530
60000				0610	0107
65000				0616	2105
70000				0719	0715
75000				0715	0733
80000				0516	0723
85000				0511	

KUSAIE-KOON SHOT, 0630M, 7 APRIL 1954

LEVEL	H-9 hours	H-4 hours	SHOT	H+4 hours	H+8 hours
Surface	1103	0903	1203	1306	1204
2000	1316	1410	1210	1212	1017
4000	1317	1116	1216	1116	1017
6000	1116	1216	1216	1016	1020
8000	1510	1309	1311	1111	1017
10000	1610	1310	1409	1412	1108
12000	1813	1510	1410	1603	1503
14000	2001	1503	2501	1304	2106
16000	0706	3404	0302	2402	2611
18000	0815	3605	1102	2506	2708
20000	1207	2705	2503	2705	3009
25000	2006	1808	2408	Missing	2209
30000	1908	1905	2107	2410	3313
35000	2208	2214	2107	2120	2122
40000	2424	2119	2121	2123	2008
45000	2123	2121	2516	2315	2019
50000	2712	2715	2708	2715	2114
55000			2624	2724	2221
60000				2205	2210
65000				2706	2619
70000				1410	2506
75000				0622	0632
80000				0927	0724
85000				0931	1020
90000				1031	

KWAJALEIN-KOON SHOT, 0630M, 7 APRIL 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0710	Missing	No Run Made	0206	0710
2000	0713	0712		0920	1025
4000	0812	0612		1020	1127
6000	1109	0907		1017	1015
8000	1315	1307		1109	1216
10000	1415	1509		1412	1111
12000	1510	1210		1413	1012
14000	1310	1309		1215	1015
16000	1309	1310		1316	0911
18000	1112	1210		1414	0812
20000	1109	1109		1510	0810
25000	1813	1612		2603	1109
30000	1011	1812		2804	0704
35000	1612	1920		2509	2613
40000	2232	2225		2317	2416
45000	2316	2422		2225	2337
50000	2719	2518		2637	2432
55000	2419	2524		2724	2636
60000	2220	0215			2405
65000		2303			0609
70000		2706			
75000		0721			

MAJURO-KOON SHOT, 0630M, 7 APRIL 1954

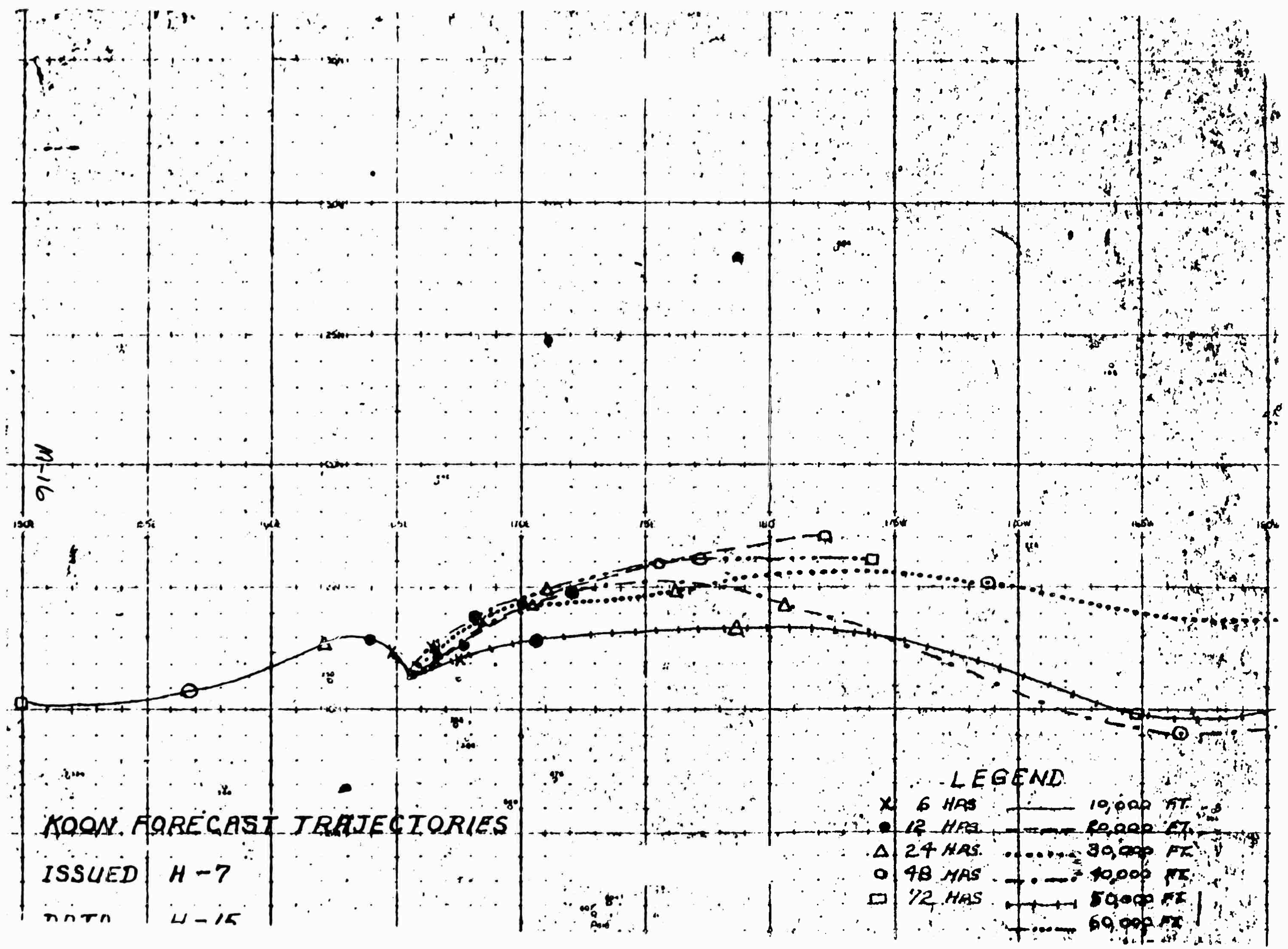
LEVEL	H-6 hours	H-3 hours	SHOT	H+4 hours	H+9 hours
Surface	0907	0913	0509	0507	0513
2000	0915	0917	0715	0821	0816
4000	1010	0915	0915	0919	0815
6000	0912	0913	0917	1018	0817
8000	1013	0915	1016	0916	0821
10000	0911	0812	1212	1018	0828
12000	0910	0909	1012	1019	0820
14000	0911	1013	1113	0914	0815
16000	1011	1011	1109	1113	1008
18000	1208	1109	1411	1406	1706
20000	1111	1008	1510	1610	1610
25000	1814	1813	2112	2207	2119
30000	1808	1708	2512	2311	2515
35000	2605	2604	2608	2618	2529
40000	2418	2420	2324	2327	2426
45000	2020	1924	2611	2023	2131
50000	2617	2612	2724	2621	2425
55000		2619	2422	2624	2636
60000		2723	3611	1517	2008
65000			1912	1913	1908
70000			0809	0516	0620
75000			0845	0846	0849
80000			0852	0854	0860
85000			0864	0866	0754
90000			0869		0878
95000			0778		
100000			0877		
105000			0787		

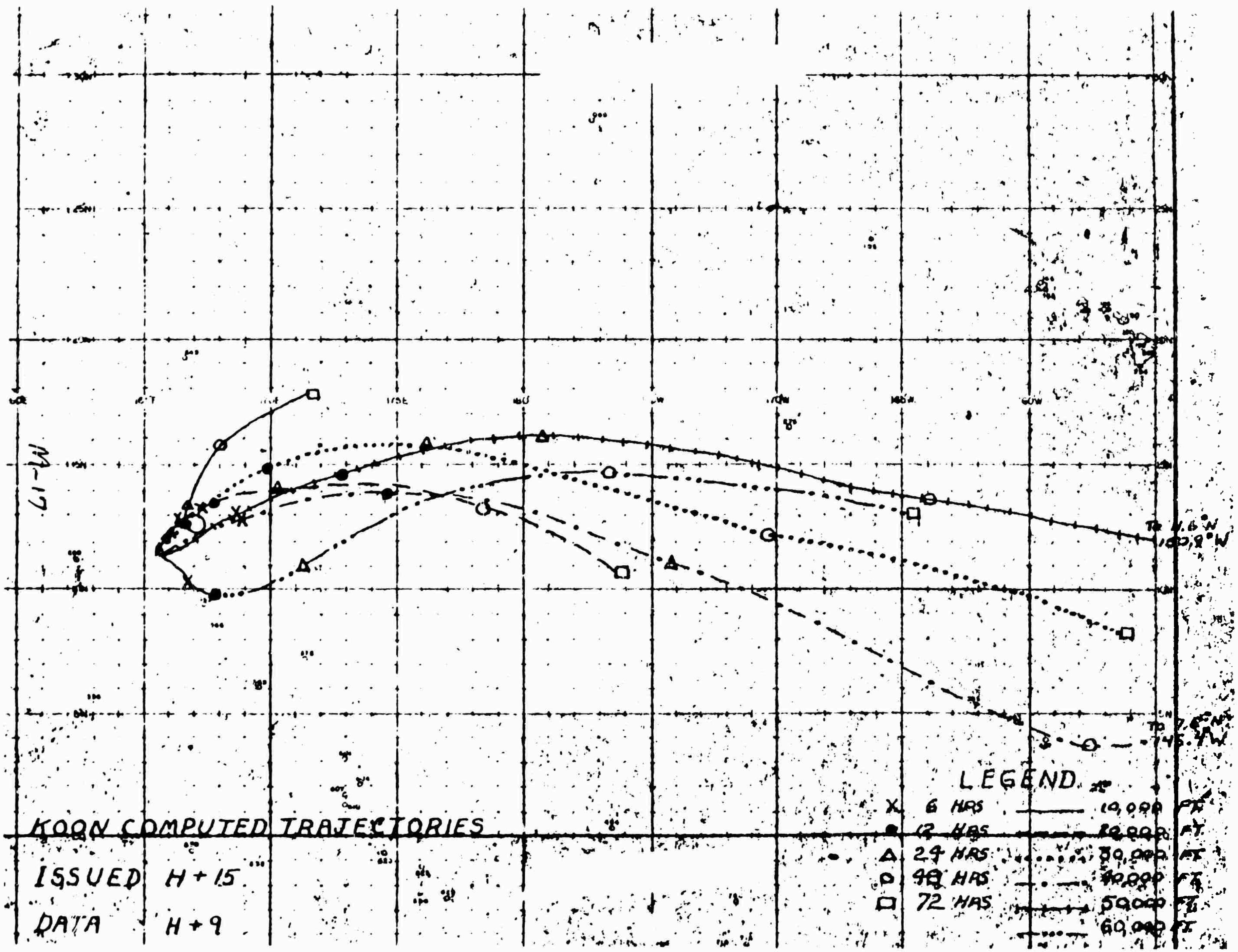
PONAPE-KOON SHOT, 0630M, 7 APRIL 1954

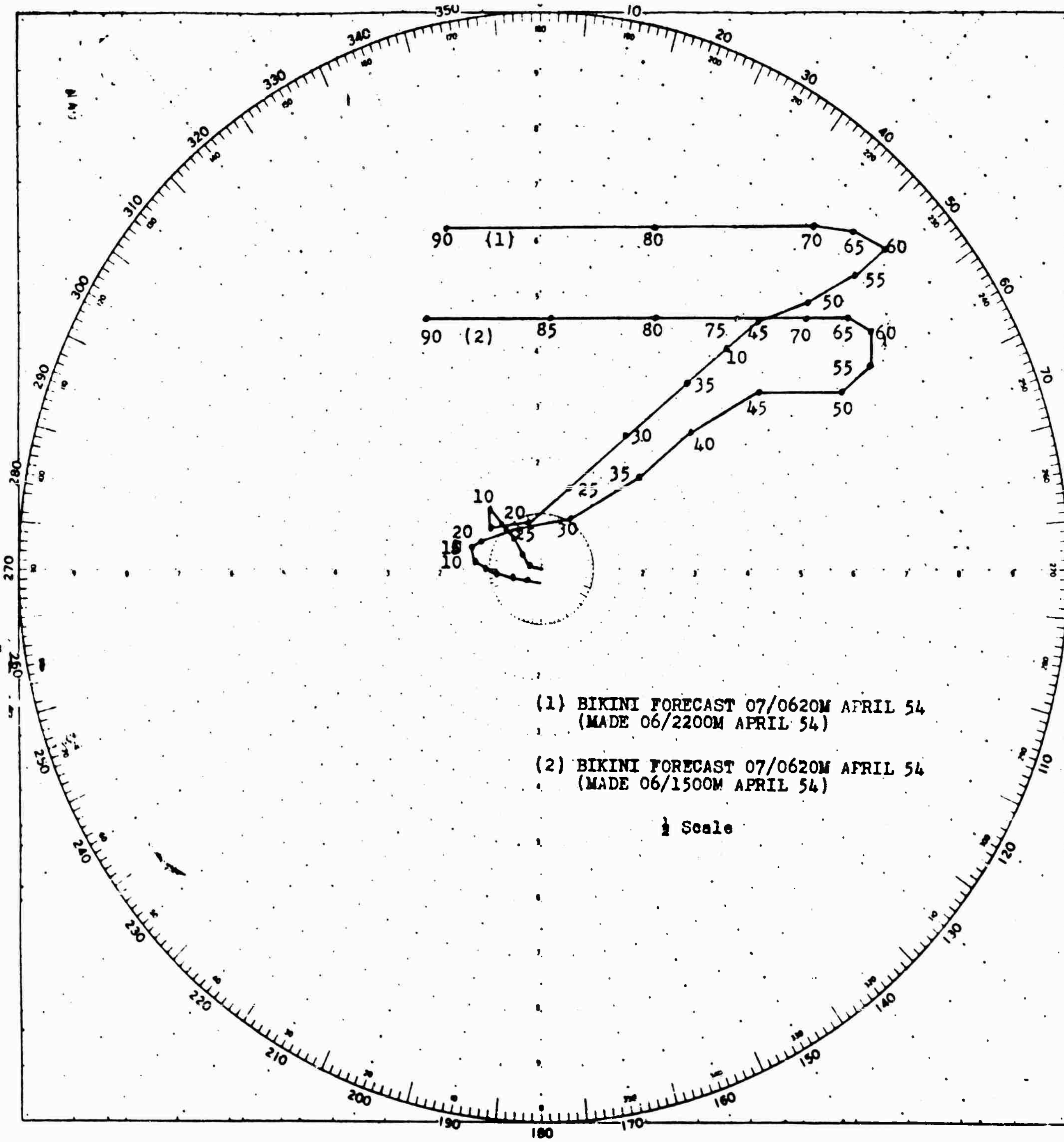
LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	Calm	Calm	Calm	Calm	0510
2000	1009	1015	1108	1116	0812
4000	1006	1110	1117	1118	1010
6000	1205	1205	1112	1115	1013
8000	1111	1015	1110	1210	1511
10000	0911	1017	1115	1213	1214
12000	0716	0911	1009	1510	1012
14000	0716	0206	0505	1510	1307
16000	0411	0405	3606	0308	1007
18000	0514	0405	0607	0308	0908
20000	1013	0611	0909	0508	1208
25000	1611	2024	2305	2205	2124
30000	1608	2017	2212	2418	2422
35000	2113	2519	2520	2420	2325
40000	2223	2327	2323	2121	2129
45000	2229	2021	2428	2528	2622
50000	2720	2728	2730	2532	2328
55000	2022	0216	2310	2411	2421
60000		3320		2407	
65000		2712		2510	
70000		1510		1403	
75000		0938		0611	
80000		1054		0720	
85000		1059		0710	
90000		0958		1345	
95000				1248	

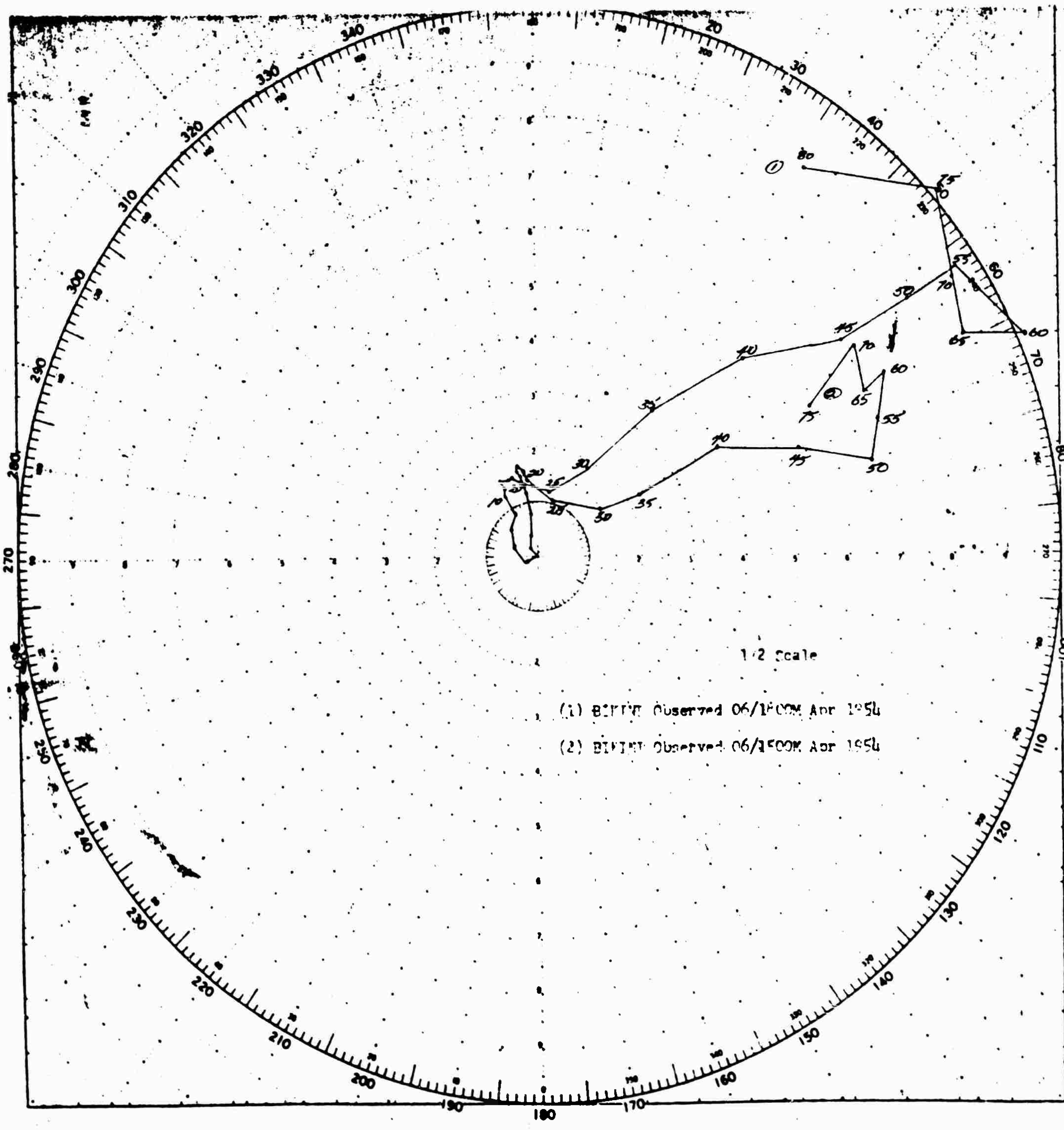
RONGERIK-KOON SHOT, 0630M, 7 APRIL 1954

No Observations Made


M-16
KOON FORECAST TRAJECTORIES
ISSUED H-7
DATA H-15
LEGEND
X 6 HRS
● 12 HRS
Δ 24 HRS
O 48 HRS
□ 72 HRS
10,000 FT.
20,000 FT.
30,000 FT.
40,000 FT.
50,000 FT.
60,000 FT.


M-17
KOON COMPUTED TRAJECTORIES
ISSUED H + 15
DATA H + 9
LEGEND
X 6 HRS 10,000 FT
● 12 HRS 20,000 FT
△ 24 HRS 30,000 FT
○ 48 HRS 40,000 FT
□ 72 HRS 50,000 FT
60,000 FT

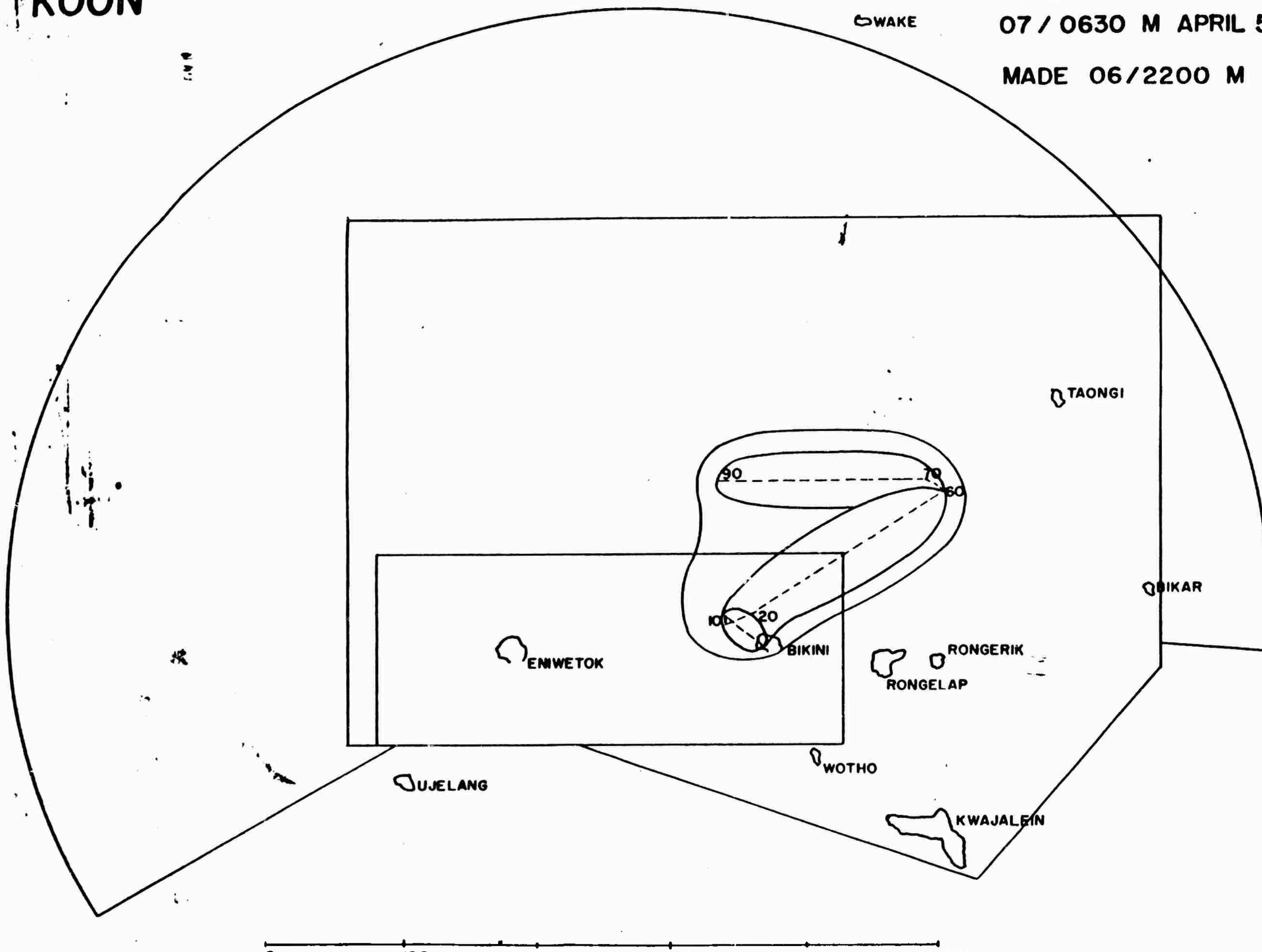

(1) BIKINI FORECAST 07/0620M APRIL 54
(MADE 06/2200M APRIL 54)
(2) BIKINI FORECAST 07/0620M APRIL 54
(MADE 06/1500M APRIL 54)
½ Scale

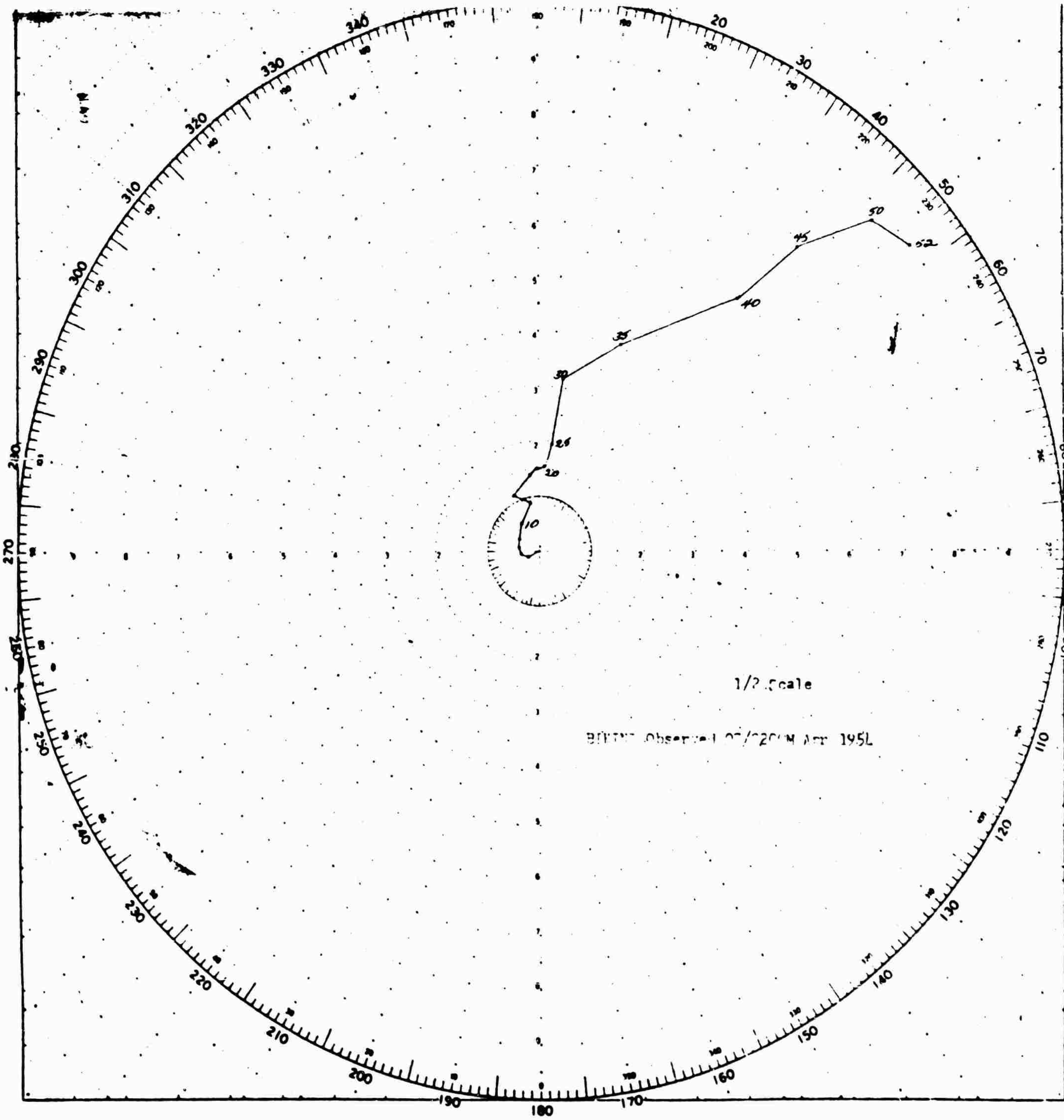

1/2 Scale
(1) BIKINI Observed 06/1800M Apr 1954
(2) BIKINI Observed 06/1500M Apr 1954

KOON

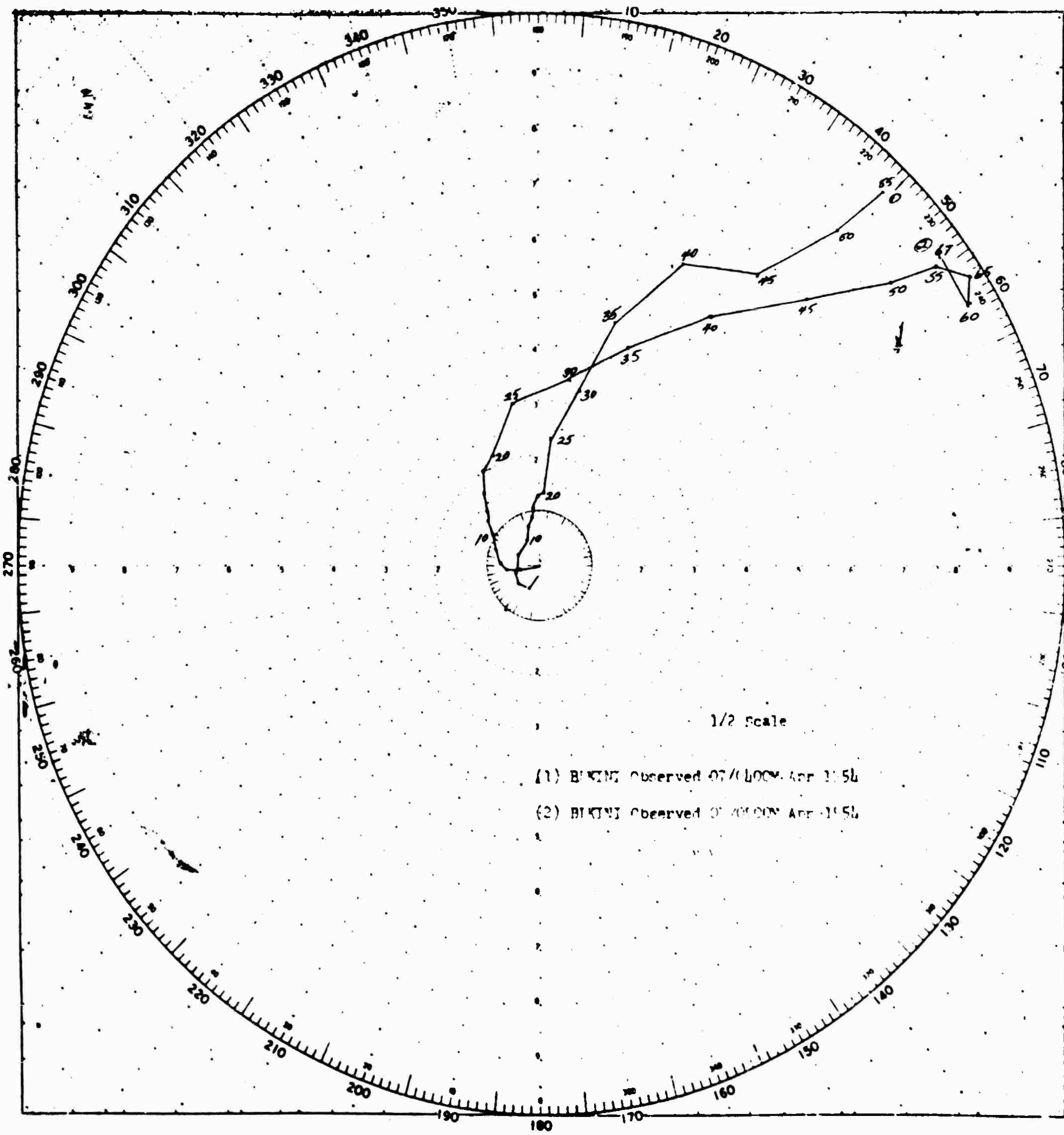
FORECAST FOR
07 / 0630 M APRIL 54

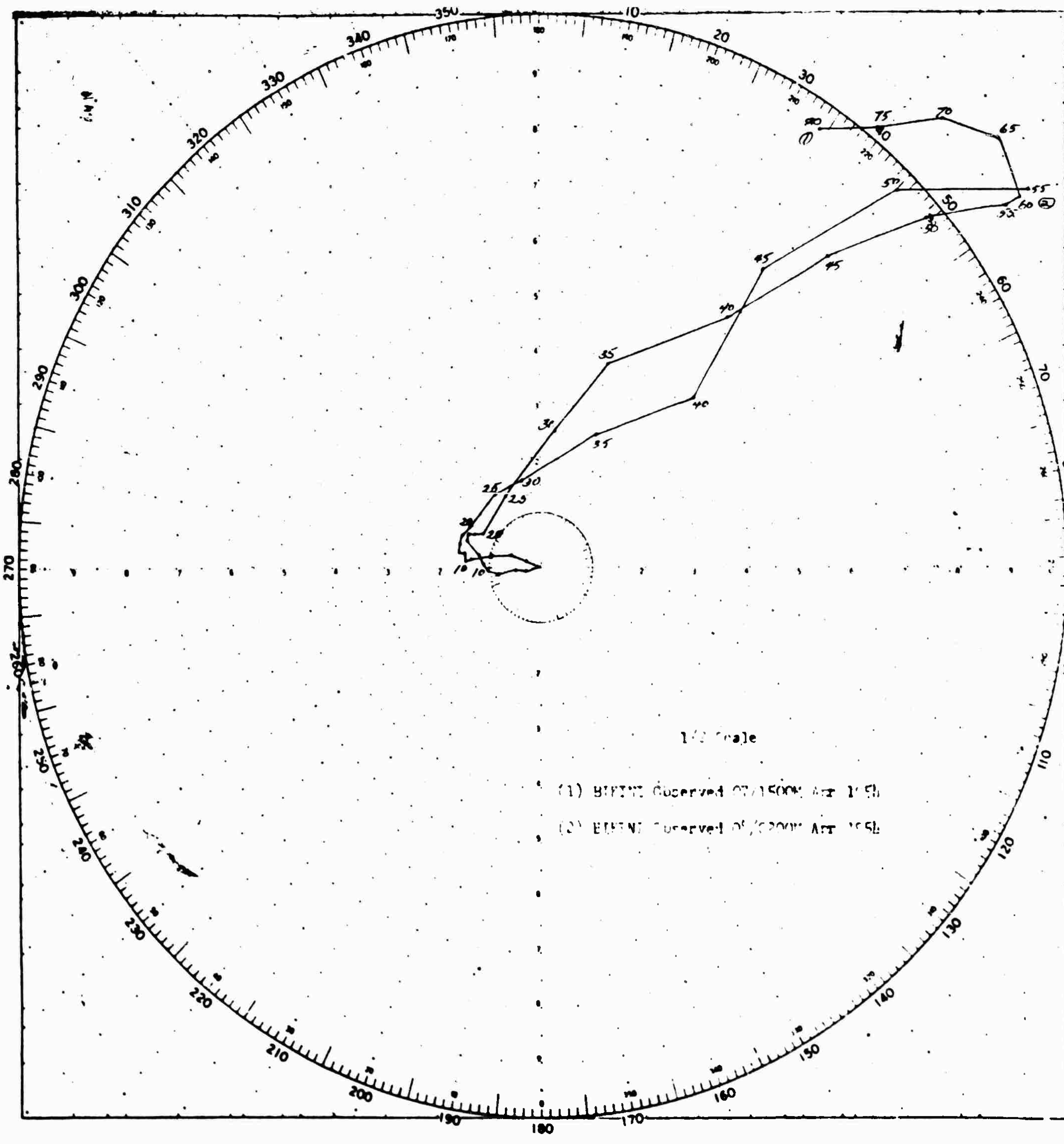
MADE 06/2200 M



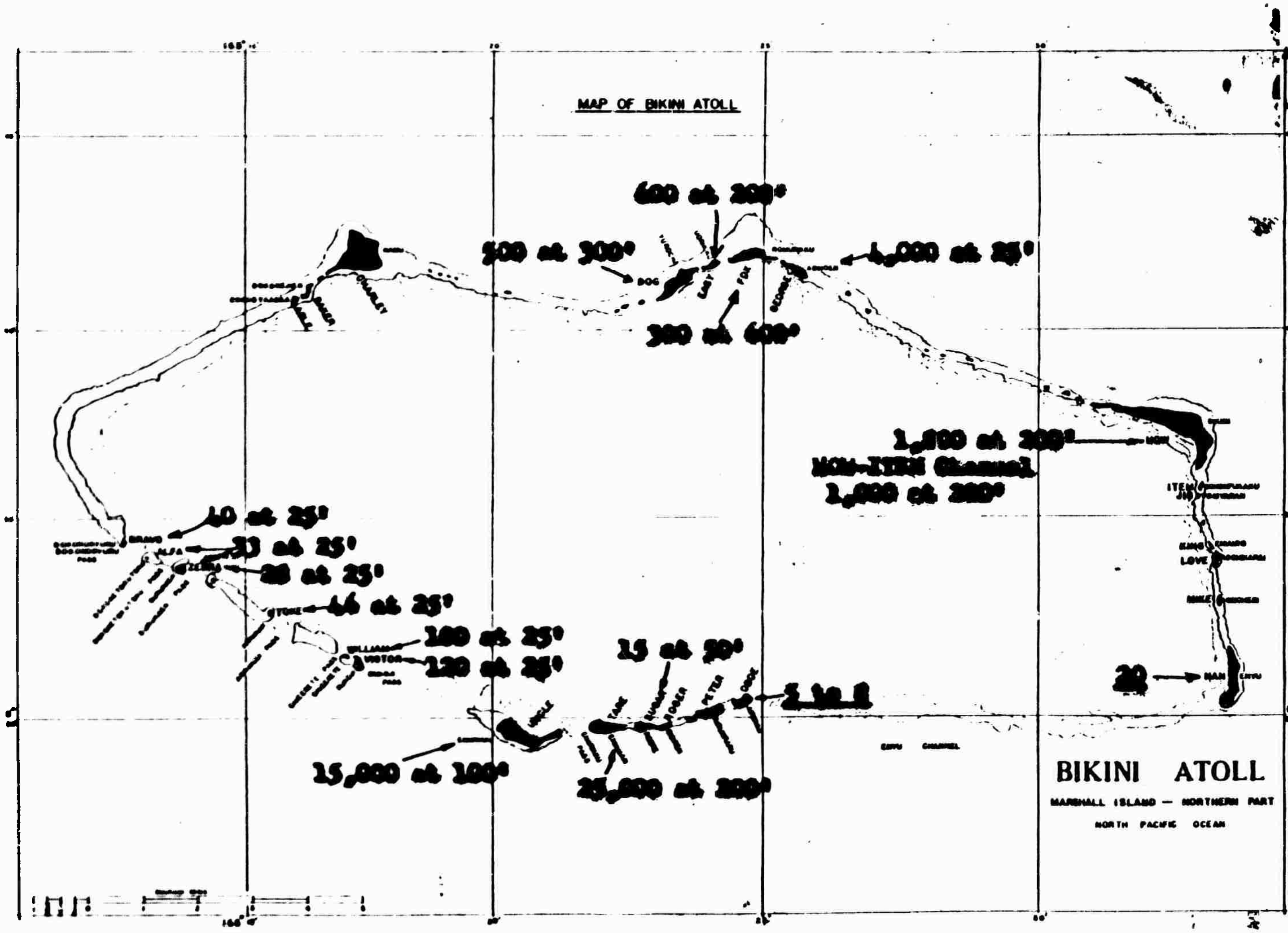


1/2 Scale
Observed
10
20
25
30
35
40
45
50
52
180
190
200
210
220
230
240
250
270
280
290
300
310
320
330
340
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170


1/2 Scale
(1) Observed
(2) Observed


(1) Observed
(2) Observed

MAP OF BIKINI ATOLL



Radsafe Survey Readings NOON Day (approximately H+4 hrs)
(All readings in mr/hr; ground readings underlined)

M-24

AIR RADSAFE OPERATIONS FOR KOON

1. SUMMARY:

The KOON cloud reached an altitude on the order of 50,000 to 55,000 feet. Air Rad Safe operations for KOON were successfully conducted and resulted in much timely information on Post-event conditions. This effort indicated that the lowest section of the cloud stem, up to perhaps five thousand feet, moved to the west at an average velocity of about fifteen knots. Contact was made with this segment of the cloud by a cloud tracking aircraft which reported a maximum intensity of 15 Mr/Hr at plus five hours fifty miles to the west of Ground Zero (BIKINI). Continued fallout and dispersion dissipated this material prior to its arrival at Eniwetok. The middle segments of the cloud (six to twenty-five thousand feet) initially moved north and then east-northeast at about fifteen knots. Contact was also made with fallout from this portion of the cloud at the forecast position. It was this level of the cloud which subsequently caused fallout on Rongelap and Rongerik Atolls. The top section of the cloud, up to fifty thousand feet, moved to the east-northeast at approximately thirty knots. Excluding the Rongelap/Rongerik contamination, there was no evidence of significant fall-out inside or outside the PPG.

2. GENERAL:

a. Sources of Information:

Cloud tracking information for KOON was available from five sources. The contribution of each of these sources, which are listed below, will be discussed in subsequent paragraphs.

Sampling Aircraft Reports
Sweet-Sour Reports
Special Cloud Tracking Flights
Weather Reconnaissance Flights
APOAT-1 Flights

b. Overall Cloud Movement (within the PPG):

The Bikini winds observed shortly after shot time were as shown by the hodographs. From the hodographs it can be seen that the KOON cloud, whose maximum height was of the order of fifty thousand feet, was influenced by two wind shears. The lowest level of the cloud (surface to four thousand feet) was influenced by the winds from the east which averaged sixteen knots. Since this segment of the cloud was so thin vertically all but the lightest particles should have fallen out within a comparatively short distance of Ground Zero. This undoubtedly was the case since it was contacted only to the west of GZ and because the ground station at Eniwetok reported no radiation readings attributable to KOON. The initial movement of the middle cloud (four to twenty-five thousand feet) was influenced by the generally southerly winds at those levels which had an average velocity of twelve knots. Subsequent movement was to the east and is reflected by the air particle trajectories. This forecast was verified by both of the KOON day cloud trackers. It was undoubtedly this segment of the cloud that caused the fallout observed on Rongerik and Rongelap Atolls following KOON. Unfortunately there is no data available on the time of fallout at either of these atolls. On the basis of the cloud tracking data it would appear that this fallout should have commenced about eight hours after the shot. The highest levels of the cloud (twenty-five thousand to the top of the mushroom at about fifty thousand feet) initially moved to the east-northeast at about twenty-five knots. This movement continued in the same general direction outside the PPG. Other than the fallout on Rongerik and Rongelap, which has been previously mentioned, no other atolls were materially affected by debris from the KOON cloud.

3. SAMPLING AIRCRAFT REPORTS:

As in the case of previous shots, these reports were recorded by RadSafe personnel aboard the command ship from plus two to plus seven hours. Reports from these aircraft provided the first data available on the maximum cloud height and initial cloud movement. The sampling activities of the planes confirmed the accuracy of the forecast air radex (see App II). As would be expected, the radiation exposure of the aircraft crews was relatively low.

4. SWEET-SOUR REPORTS:

These reports were submitted by any aircraft encountering radioactive contamination and not reporting by other means. No such reports were received following KOON.

5. SPECIAL CLOUD TRACKING (WILSON) FLIGHTS:

a. The initial phases of the KOON cloud tracking effort duplicated those which were so successfully employed for ROMEO. Two WB-29's, WILSON TWO and WILSON THREE, were placed in a holding pattern fifty miles west of Ground Zero at plus two hours. As will be seen from App. I, the location and orientation of this pattern is such that any cloud segments moving toward either Eniwetok or Ujelange should be intercepted by at least one of these aircraft. WILSON THREE, which flew at 4900 feet in the pattern, should have encountered any material being carried by the winds below the first shear level. WILSON TWO, flying at 10,000 feet, would be expected to verify any westerly movement of the middle cloud.

b. The WILSON THREE aircraft made the only contamination contact in the race-track pattern at 2335 Zebra (plus 5:15 hours) fifty miles west of Ground Zero. This contamination (15 Mr/Hr) could have had two possible sources. The first source being that of very light particles from the lowest level of the cloud. Both the air radex and the hodograph forecast such particles to arrive at this position at plus five hours. A second possible source was fallout from a higher portion of the cloud (perhaps as high as twenty thousand feet). In this event the particles would have moved first to the north and then have been carried back to the west by the "easterlies". The former source is believed most likely since the time of arrival correlates much better in that case. Had this contamination continued to move at its original speed and direction, it would have arrived in the vicinity of ENIWETOK Atoll at approximately plus sixteen hours. The fact that no such contamination was reported there is believed due to continued fallout and to dispersion. Since no further contamination was reported in the pattern, WILSON THREE was directed by Rad Safe to begin an area search to the northeast at plus six (0200Z) hours. This search was conducted at nine thousand feet. A contamination contact of 50 mr/hr was made at 0117 Z (plus 7 hours) 100 milesnortheast of BIKINI. This contact tallies well with the forecast position of fallout from the twenty and thirty thousand foot levels - especially when it is considered that as a particle fell it was influenced by winds which were slightly less strong. No further contacts were reported by WILSON THREE. This was to be expected since the remainder of the search was to the north and east of the cloud's path.

c. WILSON TWO, flying at 10,000 feet, made no contamination contacts in the racetrack pattern prior to his departure at 2250Zebra. Three contacts were reported, however, between 2348 and 0010Z in the area search to the east of Ground Zero. The maximum reading of 250 Mr/Hr was reported at 2353 Zebra, 100 miles east-northeast of Bikini, at almost exactly the forecast 0020 Zebra position of the twenty and thirty thousand foot particle trajectories. This fallout almost certainly produced the appreciable (but not hazardous) contamination of RONGERIK and RONGELAP Atolls. Subsequent reports were only aircraft radiation background.

d. Subsequent WILSON flights were cancelled when it appeared that no appreciable air contamination existed in the vicinity of the test site.

6. WEATHER RECONNAISSANCE FLIGHTS:

A PETREL LIMA weather reconnaissance flight on plus one day made a contact of approximately 3 Mr/Hr, 520 miles southwest of Ground Zero at plus 28 hours. This position agrees well with the plus 28 hour position of the very low levels of the cloud. It is more likely however that this material, which was encountered at ten thousand feet, was actually fallout from a much higher level. In that case the material would have moved to the northeast and then have been carried back to the west when the prevailing "easterlies" reestablished themselves after KOON. A second contact, this time of 4 Mr/Hr at twenty thousand feet, was made five hours later north-northeast of ENIWETOK. This material must have had a history similar to that just discussed. In both cases the contamination appears to have been confined to a relatively small area.

7. AFOAT-1 FLIGHTS:

AFOAT-1 sponsored flights made radioactive sample collections to the south of HAWAII between 8 and 10 April. In both cases the debris was found to be widely dispersed throughout the area, but as one would expect, the levels were quite low (hundredths of an Mr/Hr). The first flight reported its peak collection 170 miles southwest of HAWAII at 0200 Zebra, 9 April (plus 56 hours) at 14,000 feet. This point was directly along the path of the 40,000 foot air particle trajectory. A second peak was reported 100 miles southeast of HAWAII twenty-six hours later at 19,000 feet. Another less active sample was procured off the coast of Souther California on 12 April. Aircraft operating from GUAM made no collections of KOON debris.

8 IN-FLIGHT EXPOSURES:

All in-flight radiation exposures of the aircraft crews participating in the cloud tracking effort were well within Task Force limitations.

9. AIR RADEX:

The KOON air radex is attached as Appendix II. Because of the yield of KOON the classical radex procedure was used in this post-shot revision. The technique considers the cloud to be essentially a point source in all dimensions other than in a vertical direction. The radex proved to be a reasonably accurate forecast of the conditions subsequently observed in the sampling and tracking operations.

10. CONCLUSIONS:

a. The Air Rad Safe operations for KOON were quite successful. In particular, the cloud tracking operations early established the fact that there were no elements of the KOON cloud which necessitated the evacuation of nearby atolls.

b. Assuming that the forecast winds and trajectories are reliable, reasonably accurate forecasts can be made of the areas which will be subject to fallout.

c. No hazardous fallout appeared likely in the GUAM, PONAPE, or HAWAII areas as a result of KOON.

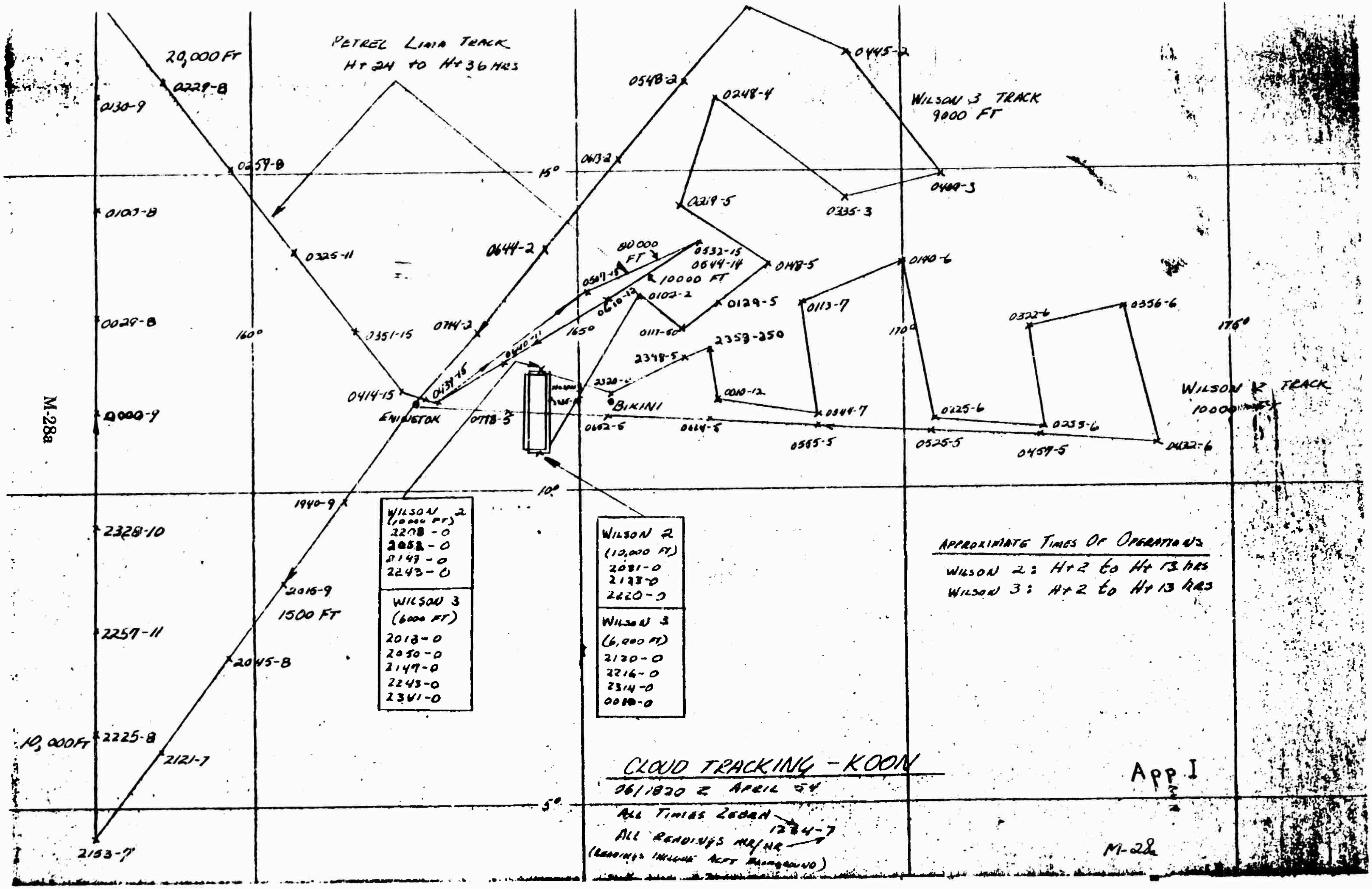
11. RECOMMENDATIONS:

None.

Appendices:

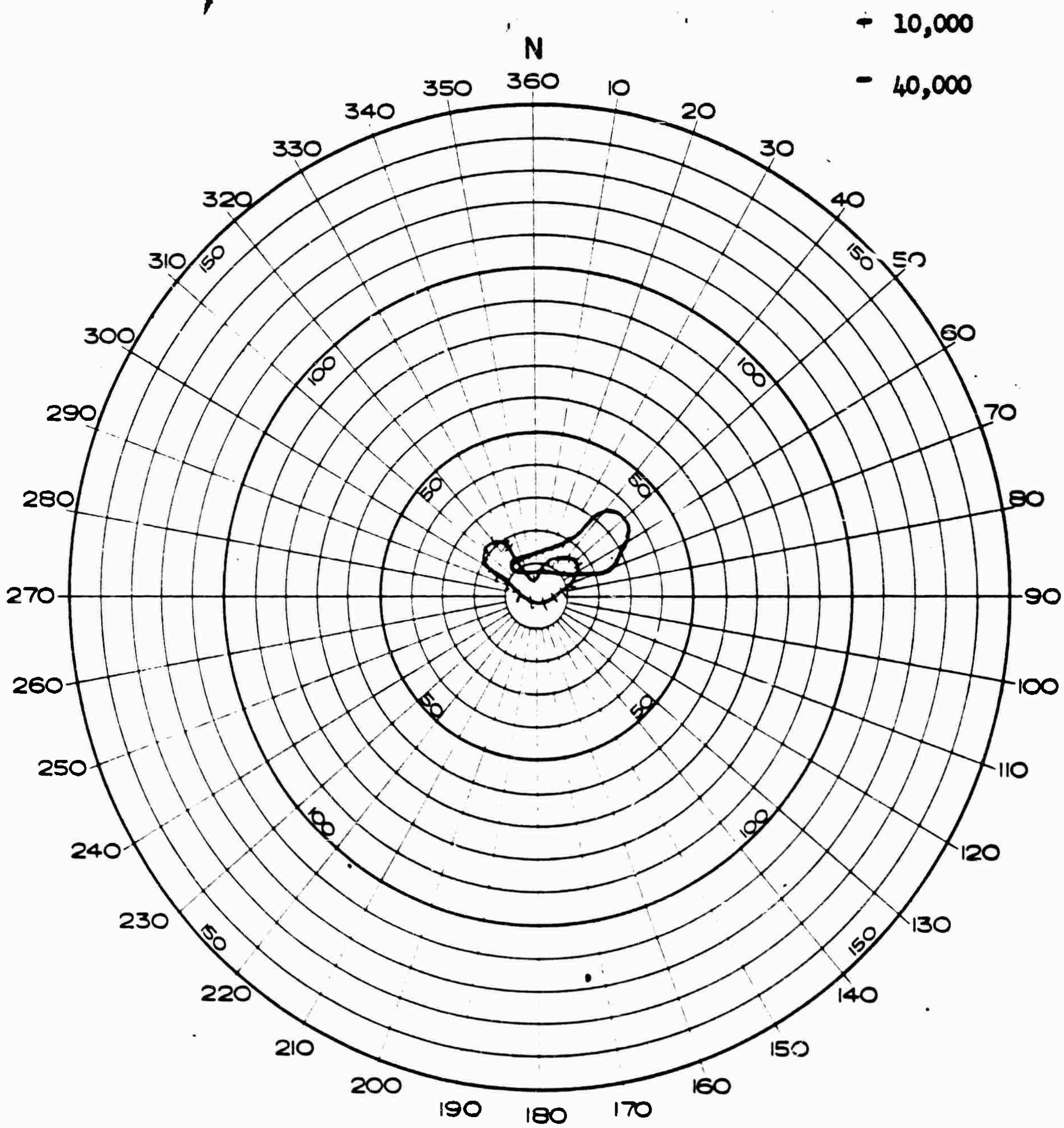
I WILSON A/C Plot

II KOON Air Radex


CLOUD TRACKING - KOON
26/1820 Z APRIL 54
ALL TIMES ZEBRA
ALL READINGS MR/HR
(READINGS INCLUDE ACFT BACKGROUND)
PETREL LIMA TRACK
H+24 to H+36 HRS
WILSON 3 TRACK
9000 FT
WILSON 2 TRACK
20,000 FT
10,000 FT
1500 FT
10000 FT
ENIWETOK
BIKINI
APPROXIMATE TIMES OF OPERATIONS
WILSON 2: H+2 to H+13 HRS
WILSON 3: H+2 to H+13 HRS
WILSON 2 (10,000 FT) 2081-0 2133-0 2220-0
WILSON 3 (6,000 FT) 2120-0 2216-0 2314-0
WILSON 3 (6000 FT) 2018-0 2050-0 2149-0 2243-0 2341-0
App I
M-28

HODOGRAPH

RESULTANT WINDS AND SURFACE RADEX



KOON AIR RADEX FOR KOON PLUS ONE HOUR

M-28b

PRELIMINARY RESULTS NYKOPO AIRBORNE MONITORING SURVEY FLIGHTS o/a 7 APRIL 1954 (CONDUCTED BY HEALTH AND SAFETY LABORATORY, NEW YORK OPERATIONS OFFICE, AEC)

LOCATION (Atoll unless otherwise indicated)	LOCAL TIME (APRIL)	MAXIMUM GRND READINGS (mr/hr)	LOCAL TIME (APRIL	MAXIMUM GRND READINGS (mr/hr)
ABLE				
LAE	080915	0.17	120920	0.04
UJAE	080930	0.25	120930	.02
WOTHO	080956	1.1	120959	0.25
AILINGINAE	081022	57	121059	7.7
RONGELAP Island	081033	94	121109	17.8
RONGERIK	081047	82	121124	18.6
TAONGI	081210	0	121247	0.04
BIKAR	081312	20	121345	8.0
UTIRIK	081332	12	121415	3.8
TAKA	081338	16	121422	1.9
AILUK	081355	1.7	121441	0.8
JEMO	081407	2.0	121452	0.4
LIKIEP	081414	1.2	121457	0.04
KWAJALEIN	081454	0.53	121200	1.5*

*Ground observation (probably erroneously high reading)

BAKER		
NAMU	120916	0.4
AILINGLAPALAP	120937	0.4
NAMORIK	121013	0.3
EBON	121037	0.2
KILI	121104	0.3
JALUIT	121116	0.3
MILI	121201	0.8
ARNO	121225	1.2
MAJURO	121245	0.2
ANI	121309	0.2
MALOELAP	121328	0.2
ERIKUB	121352	0.2
WOTJE	121404	0.8
KWAJALEIN	121452	0.4

SUMMARY OF THE STATUS OF TRANSIENT SHIPPING IN THE PPG AREA O/A 7 APR 1954

1. Task Force sources of information:

a. USS RECLAIMER, 10-45N, 168-05E, course 270, SOA 10 knots at 061200M, diverted to KWAJALEIN, ETA 070700M.

b. LST 1146, 9-35N, 169-00E, course 94, SOA 9 knots at 061200M. At 061400M alter course to 53. At 070110M alter course to 90.

c. USS UNADILLA, 7-20N, 159-30E, course 117, SOA 10 knots at 061200M At 061530M alter course to 94.

d. USS HANNA DDE at MATALANIM Island at 061200M, thence to PONAPE.

e. USNS GEN MORTON, 20-37N, 176-12E, course 267, SOA 15.8 knots at 061200M.

f. USS KARIN at ENIWETOK at 061200M.

g. USNS BARRETT (T-AP 196), 20-18N, 169-40E, course 87, SOA 15.8 knots at 061200M.

h. Visual/radar contact by search aircraft on Japanese fishing boat 19-28N, 171-56E, course 125, SOA 8 knots at approximately 051730M. Subsequent visual/radar contact by search aircraft at approximately 061800M (one Japanese fishing boat, 18-15N, 172-11E, course 100, SOA 6 knots), evaluated as the same vessel.

i. Visual/radar contact by search aircraft, one Japanese fishing boat 19-00N, 171-32E, course 315, SOA 10 knots at approximately 051730M.

j. Visual/radar contact by search aircraft, one Japanese fishing boat, 15-01N, 169-31E, course 335, SOA 6 knots at approximately 061600M. Subsequent visual/radar contact by search aircraft at approximately 061900M (one Japanese fishing boat, 15-25N, 169-21E, course 340, SOA 7 knots) evaluated as the same vessel.

2. COMNAVFORMARIANAS source of information:

a. M/V GUNNERS KNOT, PACMICRONESIAN Line vessel, TRUK at 061200M.

b. M/V ROQUE, PACMICRONESIAN Line vessel, NUKUORO at 061320M, scheduled to KAPINGAMARANGI and return to PONAPE by 10 April.

TAB "N"

UNION EVENT

TAB "N"

UNION

The first attempt to fire UNION was 16 April. The synoptic weather outlook on the morning of 15 April was such that southerwesterly flow could be expected the following morning. As a consequence the appropriate headquarters and task group staff personnel moved to BIKINI during the morning and early afternoon of 15 April. At midnight, since most of the factors to be considered were decidely unfavorable, the recommendation was made and accepted to postpone the shot for 24 hours. By 1500M 16 April neither the most pessimistic nor the most promising forecast appeared suitable. The decision was made to cancel the shot indefinitely, revert back to an 18-hour capability of firing, and return the staffs to ENIWETOK. Northerly components between 20,000 and 60,000 feet persisted until 25 April, at which time weather systems were such that, by noon, a southerly trend could be forecast for the 26th. A decision was made to shoot the following day and to perform a sector search (in addition to search of Area GREEN) 240 NM wide out to 600 NM centered on true bearing 40° from GZ. Arrangements were then made to go afloat at BIKINI, internal and external agencies were notified of the proposed shot on 26 April, and the next Command Briefing was scheduled for 1700M. In an attemp to get continuous wind-runs at RONGERIK, plans had been made to substitute a PC boat to house the detachment afloat at RONGERIK instead of flying the detachment in for runs during daylight hours only.

Prior to departure from ENIWETOK, CINCPACFLT was advised at approximately 1330M that UNION was re-scheduled for 260610M weather permitting, and that the forecast 72-hour air particle trajectories would be submitted later. The advisory further stated that no significant fall-out was forecast for populated MARSHALL Atolls and that no closure of air routes would be necessary. Further, the advisory included no health hazard problems forecast for surface routes outside Area GREEN and a statement to the effect that an intensive search of this area was being made, plus a 240 NM wide sector search out to 600 NM centered on true bearing from GZ of 40°. CINCPACFLT was requested to divert all shipping outside the new Danger Area and was advised that no known transient shipping was in the area.

By 1700M the observed lower levels had become easterly to 10,000 and westerly to 18,000, nevertheless the decision was made to continue pre-shot activities until at least midnight. At a special briefing held at 2100M the observed winds were somewhat less favorable in the lower levels, veering around counter-clockwise to 20,000 feet. Shot preparations were continued in the hope that the southwesterlies in the mid-levels would persist at BIKINI and at points to the east.

At approximately 1900M the surface and air RADEXES were issued as follows

Surface RADEX: True bearings from GZ 285° clockwise to 80° radial distance 100 NM for H to H plus 6 hours, plus a circular RADEX around GZ of 20 NM radius.

Air RADEX, H plus 1 hour, 10,000 feet and up (True bearings from GZ):

285° clockwise to 105° maximum distance 25 NM
105° clockwise to 285° maximum distance 5 NM

40,000 feet and up (True bearings from GZ):

250° clockwise to 50° maximum distance 25 NM
50° clockwise to 115° maximum distance 70 NM
115° clockwise to 250° maximum distance 13 NM

H plus 6 hours, 10,000 feet and up (True bearings from GZ):

285° clockwise to 95 maximum distance 110 NM

40,000 feet and up (True bearings from GZ):

280° clockwise to 40° maximum distance 65 NM
40° clockwise to 95° maximum distance 360 NM

At approximately 2040M the forecast 72-hour air particle trajectories were dispatched to CINCPACFLT for the ten, thirty and fifty thousand foot levels. No other change was made in the previous H minus 18 Hour advisory.

At the 0100M Command Briefing the forecast winds for H-Hour were east northeast and light in the lower levels turning around counterclockwise with increasing altitude, but light enough that resultant wind speeds in the direction of NAN and TARE were very low. West southwest to southwest winds were forecast between 15,000 and 50,000, westerlies from 50,000 to 60,000, and easterlies above. The radsafe situation was recommended as favorable except for the light resultant winds toward the south. In view of the latter situation, a recommendation was made to move the task force ships out to a point 50 NM southeast of GZ, except for those ships required to be in closer for operational reasons. No transient ships were known to be in, or approaching, the H-Hour fall-out pattern. The decision was made to shoot on schedule and to move the fleet as recommended except that ships required to be close-in for operational reasons would move south immediately after H-Hour. It was also decided to make a further weather/radsafe check at 0400M. The forecast fall-out plot by elliptical approximation is included in Incl 4. The new technique, based on forecast time and space changes in the wind pattern for H to H ≠ 24 hours, save a similar fall-out pattern except that its major axis lay more along an east to east northeast line from GZ than northeast as given by the above plot.

Based on the midnight forecast H-Hour winds, the surface and air RADEXES were modified as follows:

Surface RADEX: True bearings from GZ:

240° clockwise to 270° radial distance 75 NM

270° clockwise to 80° radial distance 100 NM
Circular RADEX around GZ of 30 NM

Air-RADEX, H plus 1 hour, 10,000 feet and up (true bearings from GZ):

95° clockwise to 35° maximum distance 10 NM
35° clockwise to 95° maximum distance 35 NM

40,000 feet and up (true bearings from GZ):

85° clockwise to 50° maximum distance 25 NM
50° clockwise to 85° maximum distance 60 NM

H plus 6 hours, 10,000 feet and up (true bearings from GZ):

90° clockwise to 45° maximum distance 30 NM
45° clockwise to 90° maximum distance 180 NM

40,000 feet and up (true bearings from GZ):

85° clockwise to 50° maximum distance 80 NM
50° clockwise to 85° maximum distance 290 NM

At approximately 0030M a directive was passed to CTG 7.4 by voice and TWX reference the first two UNION cloud trackers. Wilson 2 was directed to search in the racetrack holding pattern 50 NM west of GZ from H plus 2 to H plus 5 hours at 10,000 feet, then to sector from GZ with limiting true bearings of 65° and 95° to 500 NM. Wilson 3 was directed to search in the same holding pattern, from H plus 2 hours until released, and at an altitude at the discretion of the pilot to avoid natural clouds but not in excess of 60,000 feet.

The British Sampling Unit at Kwajalein was advised of the forecast air particle trajectories, the forecast GZ winds for H-Hour, and authorised to penetrate the Danger Area if necessary, and in accordance with scramble and routing instructions to be issued at H plus 1½ hours by CTG 7.4. The advisory included a directive to file a flight plan through the Kwajalein Liaison Officer using the advisory as authority for UNION flights. (This unit did not participate on UNION due to engine failure on the one aircraft available post-shot)

During the early pre-shot morning period, the PC boat at RONGERIK was directed to have all weather detachment personnel aboard by 261200M (i.e. after rawin run) and be prepared to move south at best speed in the event of fall-out, or when so directed.

A final weather/radsafe check was made at 0400M with no change made in the original forecast. The final wind observation at BIKINI indicated a favorable shift in the lower levels such that the winds veered around clockwise with ascending altitude. Transient shipping contacts being favorable, UNION was detonated from a barge off YUROCHI in the BIKINI lagoon in approximately 120 feet of water at 260610M April 1954 without undue incident to the to the embarked task force personnel and ships. Post-shot advisories were issued prior to H plus 30 minutes to the Chairman AEC, Army and CINCPACFLT as on past shots, indicating time of detonation and a general statement of safety of personnel. The large ships, relieved of operational requirements to remain close-in, turned south to an area 50 NM southeast of GZ.

Based on a reported aerial reading in the roentgen range approximately 10 NM south of the shot atoll, Wilson 3 was diverted at approximately H plus 3 hours from the holding pattern to proceed at existing altitude to a point 20 NM south of NAN, to descend to 1,000 feet and over-fly the air strip then to return to the holding pattern. Wilson 3 was directed to make special reports at these points and when any significant radiation readings were obtained. For the airstrip, Wilson 3 was also directed to report any visual observations of the condition of the strip. Radiation readings on this special survey were essentially insignificant except for a 6 mr/hr reading over the strip at 1,000 feet. Wilson 3 reported the strip and outhern islands flooded and covered with debris. Subsequent ground survey of the strip indicated the major portion of the Wilson 3 reading of 6 mr/hr probably was a combination of aircraft background and aerosol-type cloud in the vicinity.

On the basis of the Wilson 3 survey, a recommendation was made and accepted to approach the shot atoll with the fleet to a point 10 south of NAN in preparation for the preliminary damage survey. Considerable time had been lost in moving the large ships south and in checking the reported high intensity south of the atoll. In view of the small amount of experience with water surface shots (ROMEO being the first in U.S. testing history), cautious actions were imperative. Subsequent movements and events on shot day were delayed for approximately one to two hours, a factor of considerabley less importance than taking an unnecessary risk with the embarked task force.

Wilson 2 and Wilson 3 detected no appreciable contamination moving toward ENIWETOK or UJELAND during the morning of shot day. As a consequence, Wilson 2 proceeded to the upwind sector at H plus 5 hours. Wilson 3 was retained longer in the holding pattern to provide a safeguard agains any unusual circumstances, but was directed by 1400M to an upwind sector from GZ with limiting true bearings of 85° and 115° out to a maximum distance of 500 NM. The altitude was specified not in excess of 1,500 feet. Wilson 3 was directed to make a minimum altitude survey over each atoll in the sector area and to report the results of each such survey in addition to routine reports. (This survey, made between 1500M and 1900M, indicated the following atolls with insignificant contamination: AILINGINAE, RONGELAP, RONGERIK, BIKAR, UTIRIK, TAKA, AILUK, JEMO, WOTJE, MEJIT and LIKIEP. Survey altitudes ranged from 300 to 600 feet. Although some readings were as high as 7 mr/hr at 450 feet, much of these reading were aircraft background.)

Based on the results of Wilson 2 in the upwind sector (small amounts of contamination in the vicinity of RONGELAP) it was recommended that the PC boat at RONGERIK move at least 50 NM to the south as a precaution. This was accepted, the PC boat subsequently being moved completely out of the area (for refueling and re-supply as well as radsafety reasons). The PC boat departed RONGERIK at 261330M to 10-27N, 167-27E, SOA 18 knots, thence to BIKINI via route points 10-22N, 166-56E and 10-32N, 166-04E, SOA 12 knots, estimating BIKINI at 270500M with the entire weather detachment and project 6.6 personnel on-board.

Based on the preliminary helicopter damage and radsafe survey made about H plus 6 hours, an alert advisory was issued to all task force units. This advisory indicated that OBOE and the air strip were not appreciably contaminated but that the strip was debris ridden to the extent that flight operations would be impractical for at least UNION day. Further, it was indicated that NAN read 240 mr/hr at 25 feet and that the water in the vicinity of the NAN anchorages was not believed contaminated to a significant degree. R-Hour was expected to be 261430M. CTG 7.3 was directed to have the task force vessels stand off the lagoon entrance at 1400M pending the outcome to the lagoon water sampling of the NAN anchorages. Upon confirmation of R-Hour all units were directed to commence re-entry in accordance with previous instructions.

By 1400M, the lagoon water from the NAN anchorages having been examined and found relatively free of contamination, a firm R-Hour advisory was passed to all units. This advisory stated that cloud tracking and other operational flights since H-Hour indicated no radiation hazard to surface operations or to flight operations at any altitude south of BIKINI and that the water at the NAN anchorages was below safe radiation limits. R-Hour was announced for 1430M. A directive was included that, effective at R-Hour, recovery operation were to be controlled by the Radsafe CENTER of TG 7.1. Also, all water and air traffic in the vicinity of the NAN anchorages and to the air strip was declared radsafe unrestricted provided no landings were made on islands west of SUGAR. All other water and air traffic was made subject to clearance by the Radsafe CENTER. Swimming in the lagoon was prohibited until further notice. At R-Hour, all units were directed to commence re-entry to the NAN anchorages in accordance with previous plans. Prior to re-entry, CTG 7.3 directed all ships at BIKINI, until notified otherwise, to be ready to get underway on 30 minute notice after anchoring. Use of evaporators was authorized. The ships were also directed to keep wash down systems ready for immediate use except when this would interfere with essential ship actions.

Wilson 4 was directed at H plus 4 hours to perform his search centered on RONGERIK with limiting true bearings of 65° at 10,000 feet from H plus 12 to H plus 24 hours, thence to 15N, 163E to base. Since the Wilson 3 search pattern did not ultimately include WOTHO Atoll, Wilson 4 was later directed to pick up the minimum altitude survey of this location in addition to his regular mission. No significant contamination was observed on the 2400M, 200 foot survey of WOTHO on shot day.

Cloud tracking efforts subsequent to re-entry were mostly routine and apparently in good agreement with the forecast. Details are included in the inclosure attached hereto. By the evening of shot day, it was apparent that no further cloud tracker flights would be required following Wilson 4. CTG 7.4 was notified accordingly. NYKOPO Flight Able was scheduled for 27 April and requested to report accumulated data in flight when over TAONGI Atoll.

At 1900M on shot day a report was received from the radsafe monitoring system at ENIWETOK to the effect that FRED, ELMER and URSULA were reading background.

In accordance with plan, CINCPACFLT was advised 2000M on shot day of the current radsafe situation. This advisory consisted of the following: No significant change in the forecast 72-hour cloud trajectories, no significant fall-out known to exist or forecast for surface and air routes and for populated atolls. The advisory further stated that cloud tracking flights on shot day indicated that the main portion of the cloud passed to the east northeast and well to the north of a line through RONGELAP and UTIRIK. CINCPACFLT was informed that NYKOPO Flight Able was scheduled for 27 April and that the results of any UNION reading in excess of 10/mr/hr would be reported in the next advisory.

During the shot day and throughout the night, a small amount of light secondary fall-out was encountered by come of the ships as indicated below:

USS COCOPA	262200M	Average 2 mr/hr, maximum 4 mr/hr.
USS MENDER	262100M	Average 2 mr/hr, maximum 4 mr/hr.
USS SHEA	270730M	Average 3 mr/hr, maximum 5 mr/hr.
LST 1157	261930M	Average 2 mr/hr, maximum 3 mr/hr.
USS NICHOLAS	261320M	Average 15 mr/hr, maximum 25 mr/hr.
	261416M	Average 37 mr/hr, maximum 110 mr/hr.

(Note: NICHOLAS at 261443M reported all clear, ETA BIKINI 261745m.)

On U plus 1 day the second and final 2000M advisory was dispatched to CINCPACFLT, stating that further advisories would be contingent on future circumstances. The advisory indicated no significant change in the forecast 72-hour cloud trajectories and included a preliminary report of Flight Able on U plus 1 day which indicated no atoll through TAONGI reading in excess of 10 mr/hr from UNION. The advisory included a statement that, based on low level cloud tracker flights on UNION day, significant intensities were not anticipated for the remainder of the atolls on Flight Able. (This was subsequently confirmed, including KWAJALEIN, upon receipt of the Flight Able Final Report.)

On 1 May, information received from CTG 7.3 relative to ship contamination was passed to CINCPACFLT in accordance with a post-BRAVO request by CINCPACFLT for such information. The advisory indicated that insignificant contamination was experienced due to fall-out. It further indicated that the lagoon contamination was presenting more of a problem, but that solutions were being effected without delay to the program and without anticipated overexposure to personnel.

Since the activities of the AEC New York Operations Office had a considerable impact on task force post-shot off-site radsafe operations, the final report of this agency is suggested as additional information on the long-range aspects of UNION.

7 Incls:

1. An Evaluation of Weather Forecasts for UNION
2. Tabulation of UNION Pre-shot and Post-shot Winds from Task Force Station
3. Forecast and Computed UNION Air Particle Trajectories
4. UNION Ground Zero Hodographs
5. UNION Shot Day Ground Radiation Intensities On-site
6. Air Radsafe Operations for UNION
7. Preliminary Results of NYKOPO Airborne Monitoring Survey Flights o/a 25 April 1954
8. Summary of the Status of Transient Shipping in the PPG Area o/a 26 April 1954

AN EVALUATION OF WEATHER FORECASTS FOR UNION

1. Summary of weather immediately prior to U-Day: At noon on the day preceding the shot, it was felt that there was a good chance for the indraft at 10,000 feet (which had broken off the ENW-WSW trough at 201500Z April near 13N 175E and had drifted to 10N 160E) to expand and give southerly winds over the Northern MARSHALLS. A forecast was issued to this effect. On the basis of this forecast an H minus 18 hour forecast was called for. The indraft continued to move over ENIWETOK at 20,000 and 25,000 feet but was poorly located below 20,000 feet. It was reasoned that since the indraft was expanding, it would move little and keep the winds over the target area generally southwesterly at levels 20,000 feet and up. At ENIWETOK, however, westerly to northwesterly winds would prevail at 30,000 feet.

Reconnaissance flights had been finding a great deal of weather between 10N and the equator and westerly winds about 2N. A weak center appeared at 1500 feet at 3N 168E around noon.

2. The Weather Forecast: 5/8 cumulus, base 1800 feet, tops 8000 feet, with scattered isolated tops to 16,000 feet; 4/8 altostratus, base 19,000 feet, tops 21,000 feet; 4/8 cirrus, base 39,000 feet, tops 41,000 feet; scattered light rain showers.

a. Observed weather: 4/8 cumulus, base 1800 feet; 2/8 altocumulus, base 18,000 feet; 4/8 thin cirrostratus, base 40,000 feet. Very light rain showers had been reported three hours prior to shot time.

b. Comments on weather: Wilson flights (reconnaissance aircraft near shot site) reported 1/8 to 6/8 cumulus, tops 3500 feet to 12,000 feet, generally being around 8,000 feet; 1/8 to 3/8 altocumulus, base 20,000 feet; and 4/8 to 8/8 cirrostratus at 45,000 feet, following the detonation. Between four to seven hours after the shot, light scattered rain showers were reported.

3. The Wind Forecast:

HEIGHT (Thsds Ft)	H-18	H-9	H-4	OBSERVED WINDS H-Hour
[illegible]	100/50	090/60	090/60	
[illegible]	110/50	090/55	090/55	
[illegible]	110/45	090/50	090/50	
75	110/30	090/45	090/45	
70	110/15	090/30	090/30	
65	090/10	110/25	110/25	
60	300/15	270/15	270/15	
55	290/15	280/25	280/25	220/09
50	270/15	270/25	270/25	260/28
45	270/25	260/35	260/35	250/40
40	270/35	260/40	260/40	250/40
35	250/30	250/40	240/45	240/44

Incl 1:

HEIGHT (Thsds Ft)	H-18	H-9	H-4	OBSERVED WINDS H-Hour
30	240/20	240/35	220/45	250/40
25	210/16	230/35	220/40	200/33
20	170/12	240/30	250/25	260/15
15	160/15	260/10	290/06	300/16
10	150/10	050/05	050/05	110/12
08		060/08	060/08	130/17
06	(05)120/15	080/15	080/15	110/18
04		080/15	080/15	090/18
02		070/20	070/20	080/18
SFC		060/15	060/15	050/17

a. Comments on winds:

(1) 60% of the forecast wind directions were within ten degrees of the observed. 80% of the forecast wind directions were within thirty degrees. The greatest deviation from the forecast winds was 70 degrees at 8000 feet.

(2) 60% of the forecast wind speeds deviated six knots or less from the observed, and 93% deviated ten knots or less. The maximum error was sixteen knots at 55,000 feet, immediately below the tropopause.

UNION

Date 26 APRIL 1954 Time 0610 L Local Observation Time 0600 L

Clouds lower 2/10 CU SC Base 1800 Tops 3500 Middle 1/10 SC Base 12000

FEW VERY THIN CI Visibility 8 Miles

Sea Level Pressure 1007.4 Mb Wind direction 062 degrees Velocity 18 Kts

Surface temp 81 °F Dew Point 76 °F Humidity 86 % Vapor pressure 1.056

Local weather PARTLY CLOUDY Remarks NO INDUCED SHOWER ACTIVITY OBSERVED

Latest winds aloft taken on CURTISS Position BIKINI Time 0600 L

ALTITUDE	DEGREES	KNOTS	PRESSURE	TEMP	DEW POINT	REL. HUMIDITY
Surface	050	17	1006	26.8 °C	24.2 °C	81 %
1,000 Ft	060	21	979	24.8	21.7	78
1,500	070	19	958	23.3	20.3	79
2,000	080	18	942	22.0	19.4	83
3,0[illegible]	090	17	908	19.4	17.1	85
4,000	090	18	877	17.1	15.0	85
5,000	100	19	846	16.2	14.2	68
6,000	110	18	817	16.3	09.8	30
7,000	120	18	788	15.9	-02.2	45
8,0[illegible]	130	17	760	13.8	00.0	70
9,000	120	16	733	11.2	04.5	57
10,000	110	12	707	09.9	01.8	41
12,000	350	04	655	05.8	-05.4	62
14,000	360	06	608	03.5	-06.7	50
16,000	240	25	563	-01.2	-11.7	45
18,000	290	14	522	-06.0	-15.5	56
20,000	260	15	483	-09.0	-16.3	63
25,000	200	33	397	-17.9	-23.5	62
30,000	250	40	322	-26.0	MB	
35,000	240	44	259	-37.8	MB	
40,000	250	40	207	-49.5	M	
45,0[illegible]	250	40	157	-61.4	M	
50,000	260	28	123	-73.5	M	
55,000	220	09	097	-77.5	M	
60,000 (57000)	180	15	074	-79.8	M	
65,000			057	-67.7	M	
70,000						
75,000						
80,000						
85,000				N-10		
90,000						

BIKINI-UNION SHOT, 0610M, 26 APRIL 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+6 hours
Surface	0718	0616	0517	0914	0816
2000	0820	0818	0818	0919	1012
4000	1017	1016	0918	0917	0909
6000	1009	0917	1118	0815	1110
8000	0205	0502	1317	0815	1312
10000	0505	0604	1112	1014	1313
12000	3210	3110	3504	0609	0903
14000	3003	3010	3606	0207	3606
16000	3008	3016	2425	3610	3408
18000	2916	2715	2914	2608	2407
20000	2525	2627	2615	2217	2312
25000	2149	2038	2033	2229	2116
30000	2340	2343	2540	2943	2529
35000	2443	2541	2444	2642	2431
40000		2844	2540	2642	2734
45000		2629	2540	2439	2638
50000		2822	2628	2121	2643
55000		2915	2209	1125	1525
60000			1815	3402	1914
65000				1029	0917
70000				0940	1026
75000				0950	1143
80000				1031	1041
85000				0854	1241
90000				0574	
95000				3268	

ENIWETOK-UNION SHOT, 0610M, 26 APRIL 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0616	0517	0516	0417	0416
2000	0822	0821	0820	0719	0618
4000	1019	1018	1016	0817	0712
6000	0812	0813	0812	0914	1013
8000	0809	0808	0910	0914	1211
10000	1805	1718	1504	1310	0803
12000	2505	2720	2605	2305	2503
14000	3410	3214	3315	3310	0408
16000	2609	2911	3215	3307	3105
18000	2307	2211	2611	2907	3606
20000	1505	1818	2120	1918	0611
25000	0611	0517	0517	0523	2009
30000	3210	2609	3407	3307	2608
35000	2727	2627	2527	2620	2726
40000	2629	2630	2729	2626	2826
45000	2624	2628	2633	2531	2236
50000	2921	2726	2830	2737	2741
55000	0911	0907	0204	2810	2107
60000	2304	2905		Calm	3314
65000	2724	2711		Calm	1017
70000		0922		1030	0925
75000		1037		1036	1040
80000		0947		0944	1049
85000		0950		0951	0957
90000				0868	0973
95000				0970	0968
100000				0973	0950
105000				0976	

KUSAIE-UNION SHOT, 0610M, 26 APRIL 1954

LEVEL	H-6 hours	H-1 hours	SHOT	H+3 hours	H+9 hours
Surface	Calm	0604	0607	0807	0906
2000	0816	0919	1019	0921	0912
4000	0911	0721	0926	0831	1024
6000	1211	0714	0927	0823	0924
8000	0703	1212	0718	0811	0813
10000	3203	1707	1708	3502	0406
12000	2205	2104	2509	2705	0110
14000	2008	2511	2807	2310	3608
16000	2108	2515	2516	2215	2511
18000	2621	2620	2517	2525	2516
20000	2517	2420	2522	2420	2318
25000	2724	2823	2428	2625	2612
30000	2823	2721	2722	2623	2522
35000	2520	2420	2621	2621	2327
40000	2427	2327	2321	2330	2425
45000	2424	2623	2529	2524	2515
50000	3024	3035	2923	3017	3009
55000	2820	3036	2618	1506	1404
60000			1313	2914	2916
65000				2810	2611
70000				1024	1131
75000				1045	1050
80000				0952	1063
85000				0960	1067
90000				0976	

KWAJALEIN-UNION SHOT, 0610M, 26 APRIL 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0911	0912	0712	0712	0911
2000	1019	1220	1019	0818	1010
4000	1122	1226	1118	0919	1009
6000	1116	1116	0918	0814	1309
8000	0916	1112	1220	1012	1006
10000	0712	1112	1218	1021	1201
12000	0710	1011	0817	1321	1311
14000	0809	0715	0718	1317	1525
16000	0906	0519	0916	1209	1821
18000	0605	0107	1515	1711	2824
20000	2310	2106	2120	2415	2729
25000	2020	2230	2422	2324	2139
30000	2231	2232	2536	2431	2526
35000	2439	2336	2634		2641
40000	2237	2330	2535		2143
45000	2431	2535	2747		
50000	2536	2535	2669		
55000	2721	2710			

MAJURO-UNION SHOT, 0610M, 26 APRIL 1954

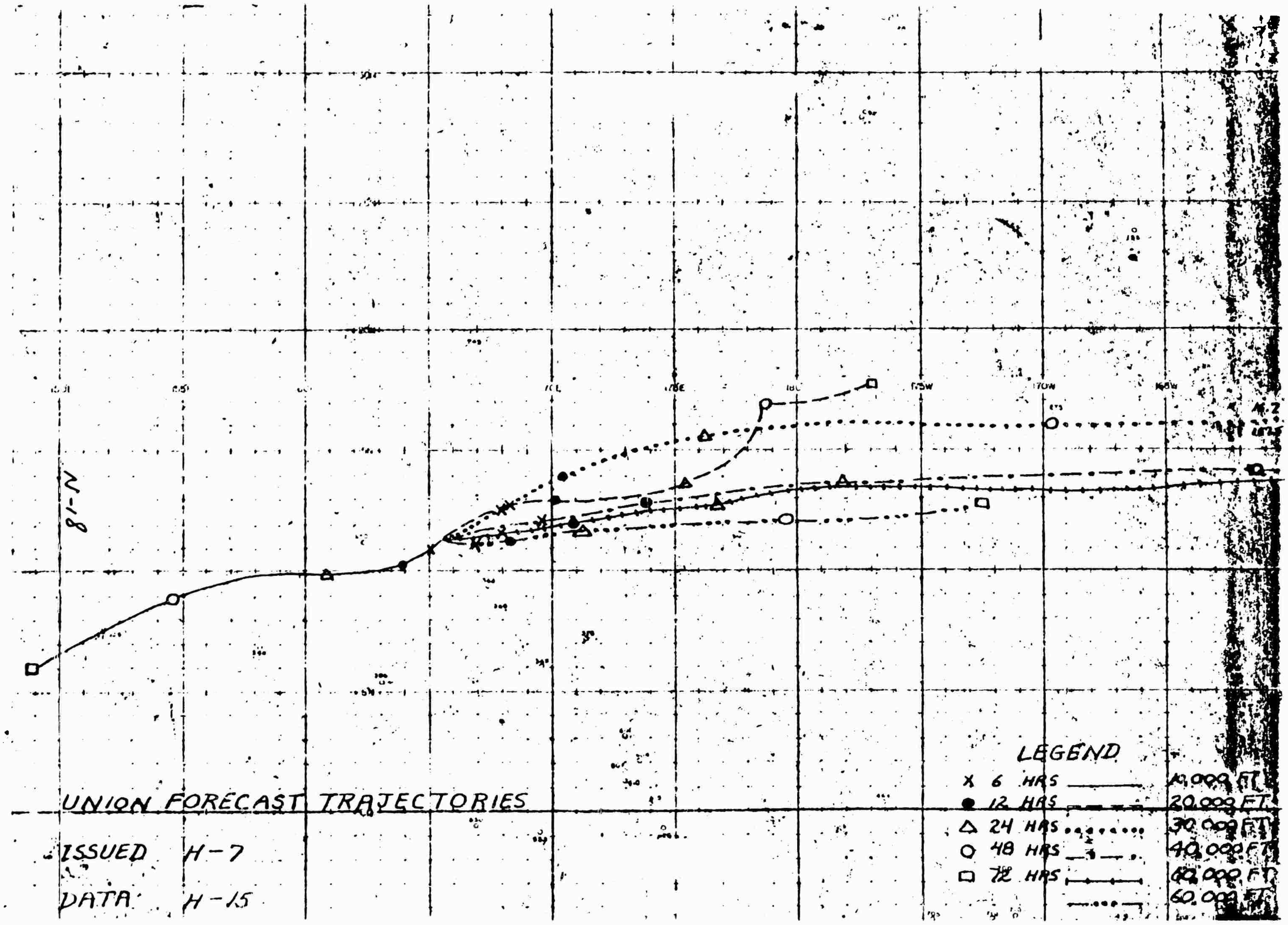
LEVEL	H-6 hours	H-2 hours	SHOT	H+5 hours	H+11 hours
Surface	0904	0309	0905	0707	0606
2000	0916	0413	0808	1019	0814
4000	0913	0912	0910	1017	1116
6000	0810	1013	1010	0918	1218
8000	0810	1013	0911	0919	1317
10000	0810	1010	0909	0914	1310
12000	0719	0812	0910	1007	1210
14000	0724	0820	1015	1107	1317
16000	1121	0923	1117	1010	1312
18000	1222	1121	1221	1209	1417
20000	1317	1320	1424	1612	1614
25000	1910	2316	1612	1213	2314
30000	2522	2424	2012	2709	2812
35000	2631	2312	2428	2213	2415
40000	2340	2232	2326	2325	2433
45000	2539	2632	2731	2642	2234
50000	3106	3103	1708	2311	2529
55000	0703		1708	2107	2128
60000				2612	
65000				3621	
70000				0930	
75000				0951	
80000				0861	
85000				0769	
90000				0881	
95000				0662	

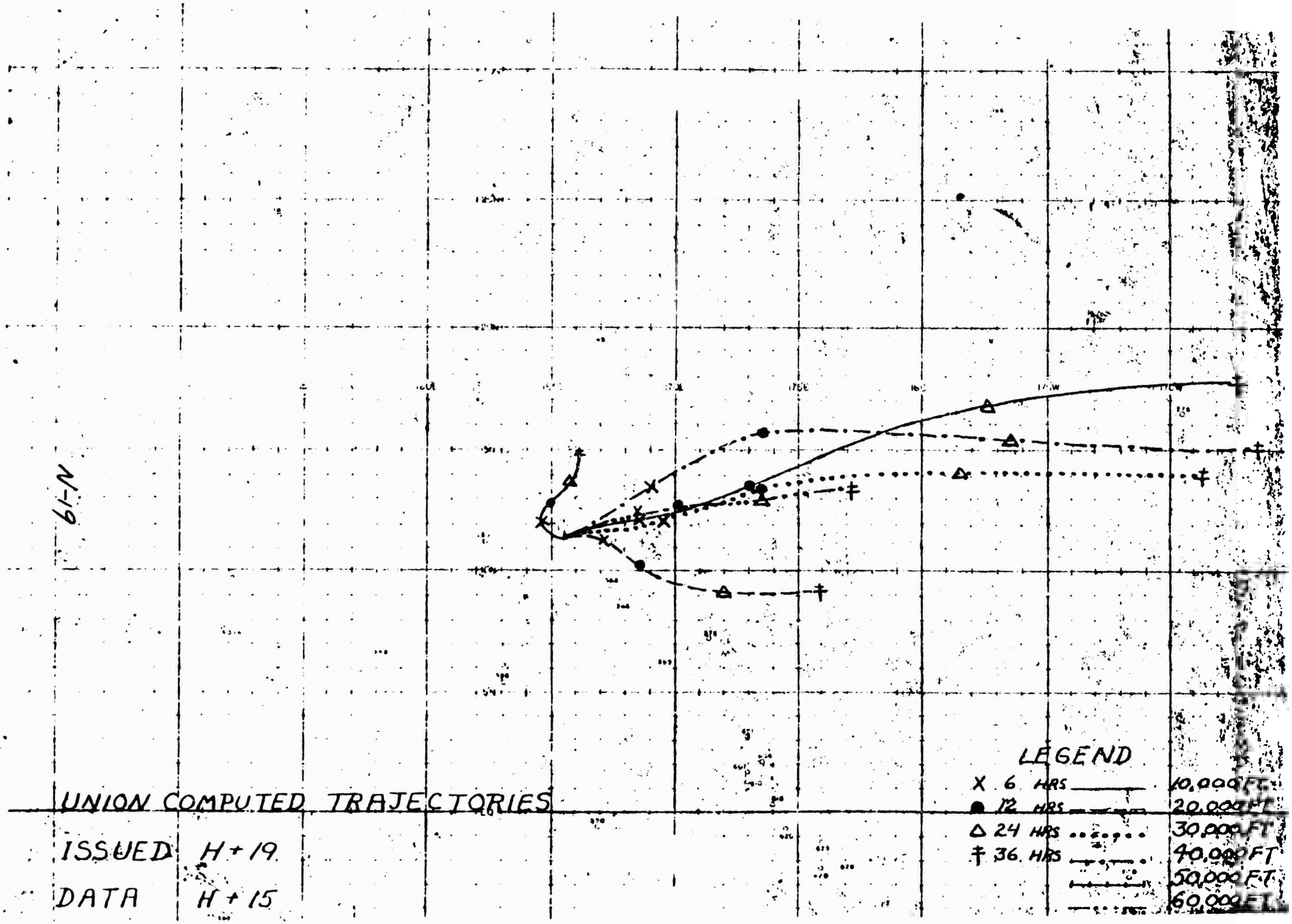
PONAPE-UNION SHOT, 0610M, 26 APRIL 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0910	0910	0910	Calm	Calm
2000	0715	0720	0716	0716	0718
4000	0717	0720	0718	0721	0823
6000	0402	0712	0714	0612	0818
8000	2802	0306	2509	3503	0807
10000	2705	2804	2807	0505	0603
12000	0502	1705	1004	0707	1806
14000	1107	0910	0910	0716	0812
16000	1407	2209	1206	0815	0715
18000	2409	2509	0502	3206	0715
20000	2510	2910	2610	2603	3106
25000	3023	3022	3115	3510	3513
30000	2830	2827	2819	2808	2806
35000	2632	2627	2623	2426	2623
40000	2633	2630	2421	2319	2426
45000	2630	2626	2625	2420	2424
50000	2719	3114	3116	3313	2007
55000	0903	1011	1215	1104	2014
60000	2817			2710	2402
65000				1138	0704
70000				0737	1130
75000				0961	0953
80000				0878	0860
85000				0983	1052
90000				1078	0980
95000					0985

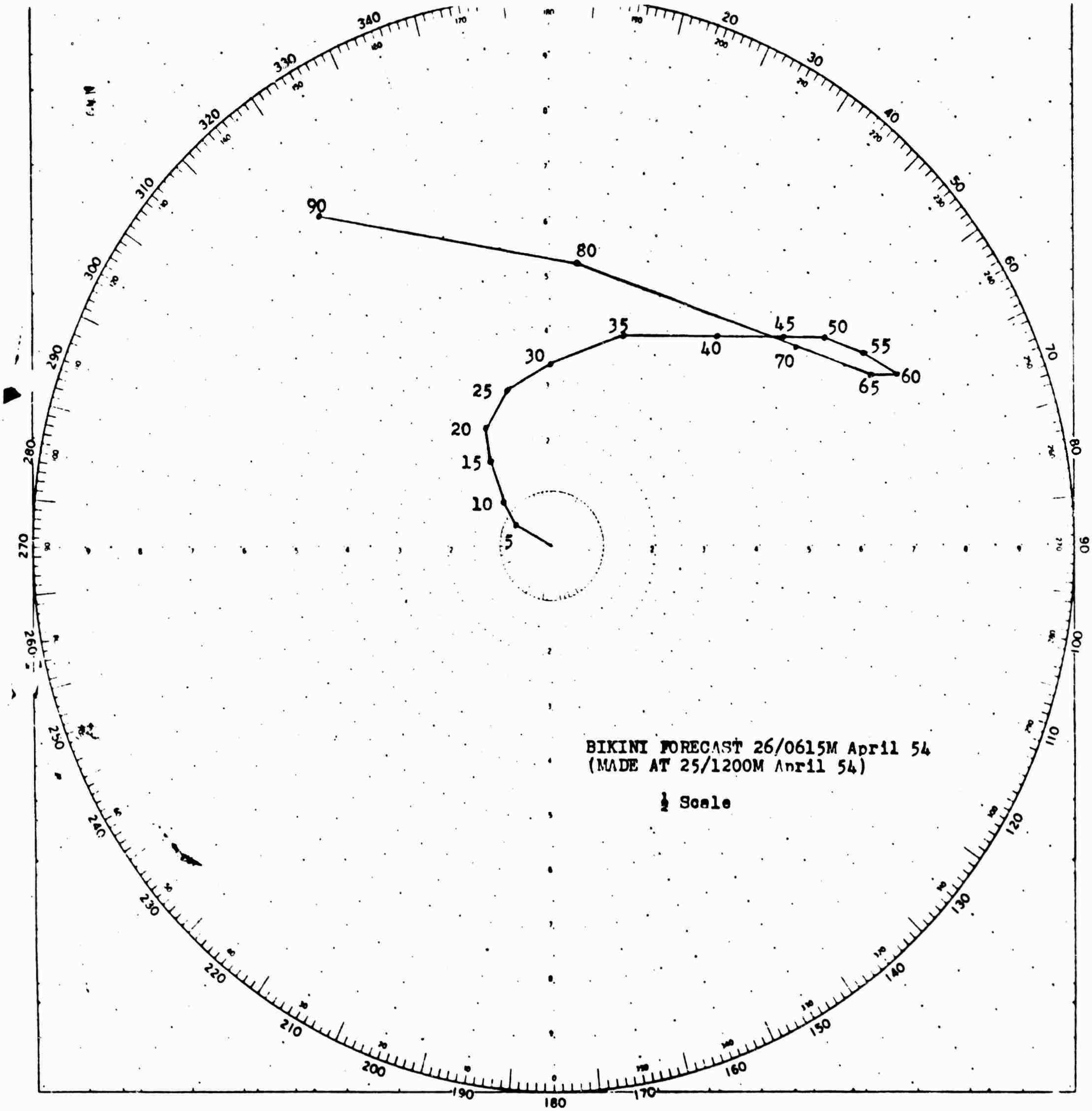
RONGERIK-UNION SHOT, 0610M, 26 APRIL 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0713	0613	No Run Made	1007	0617
2000	0717	0618		0818	0717
4000	1017	0815		0817	0821
6000	1116	1211		1114	1018
8000	0913	1211		1315	1016
10000	0909	1311		0805	1007
12000	0106	1204		3508	1106
14000	3112	2810		0507	1405
16000	3112	2811		1509	2004
18000	3020	3018		1809	2306
20000	2727	2518		2316	2710
25000	2035	2030		2023	2526
30000	2346	2447		2431	2334
35000	2563	2353		2533	2729
40000	2661	2650		2538	2734
45000	2642	2735		2540	2734
50000	2923			2731	2832
55000	0118			0803	3402
60000	2303			1707	0203
65000	0304			3308	0608
70000	1136			1124	0829
75000	1045			1041	0843
80000	0955			0950	0953
85000	0958			0952	0932
90000	0861			0851	0979
95000	0887			0968	0962
100000					0964

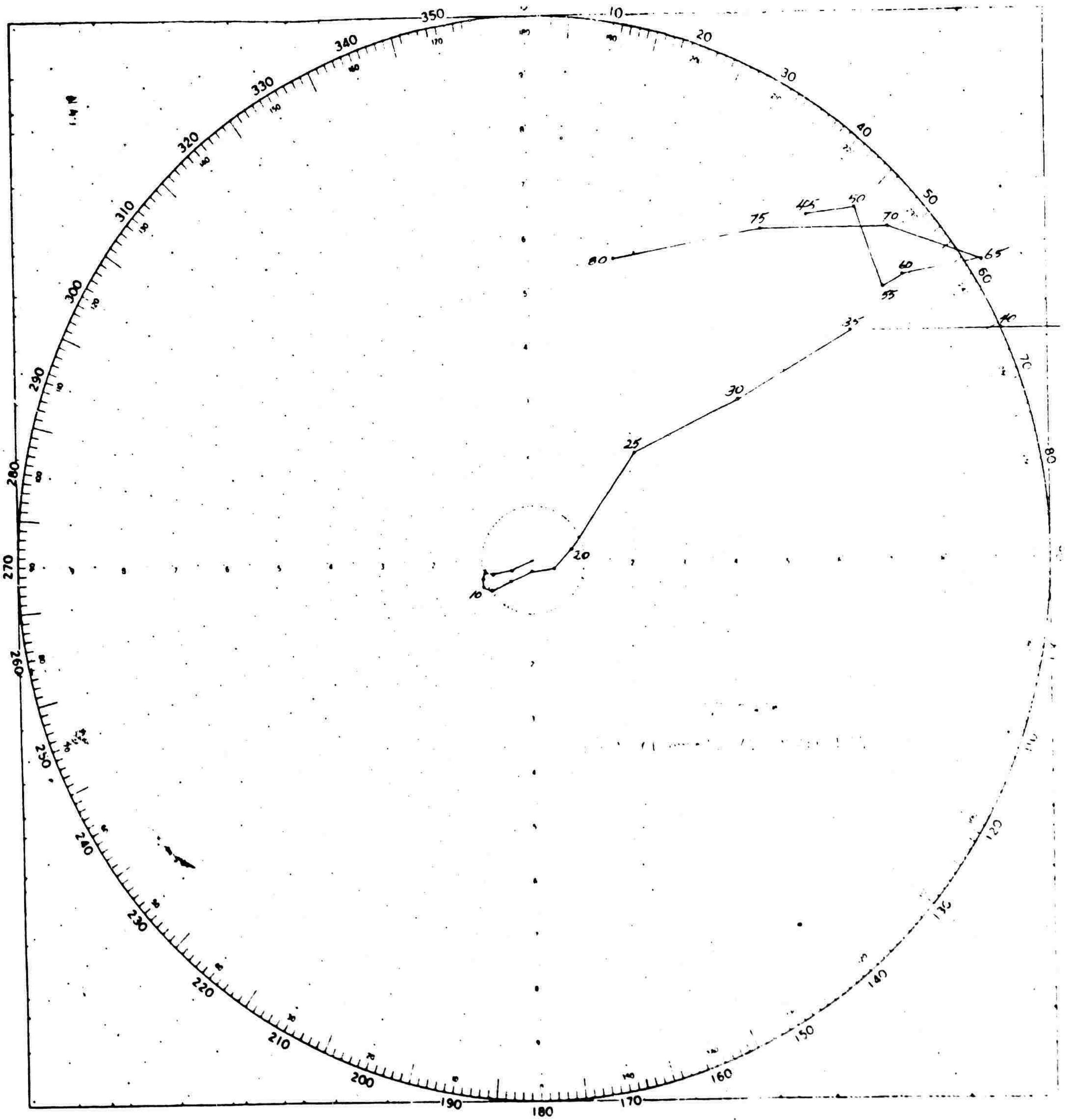

N-18
UNION FORECAST TRAJECTORIES
ISSUED H-7
DATA H-15
LEGEND
X 6 HRS
● 12 HRS
△ 24 HRS
○ 48 HRS
□ 72 HRS
10,000 FT
20,000 FT
30,000 FT
40,000 FT
50,000 FT
60,000 FT
170W
175W
180
175E
170E


UNION COMPUTED TRAJECTORIES
ISSUED H + 19
DATA H + 15
LEGEND
X 6 HRS
● 12 HRS
△ 24 HRS
ǂ 36 HRS
10,000 FT
20,000 FT
30,000 FT
40,000 FT
50,000 FT
60,000 FT

N-19



BIKINI FORECAST 26/0615M April 54
(MADE AT 25/1200M April 54)
½ Scale



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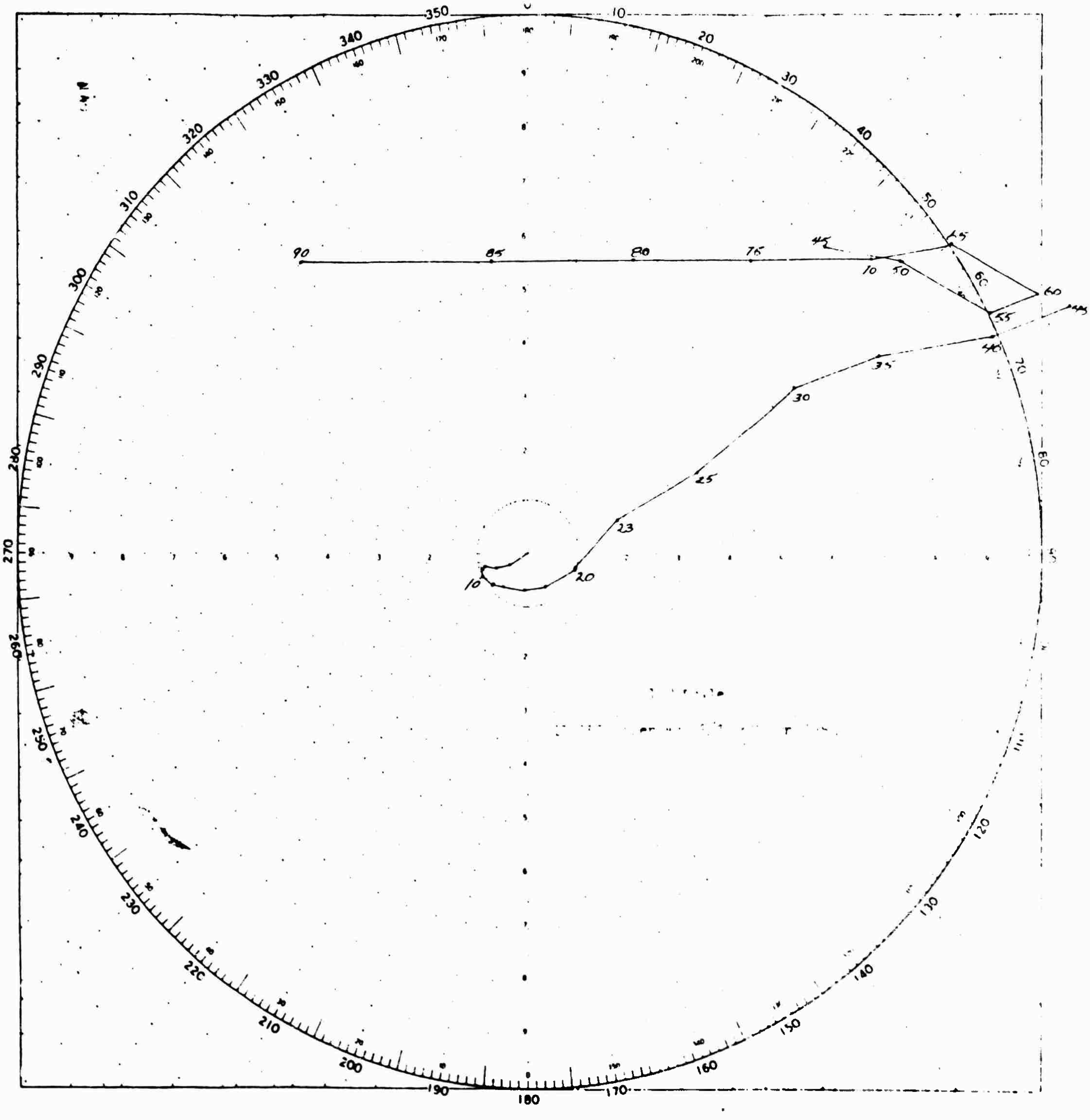
N-21



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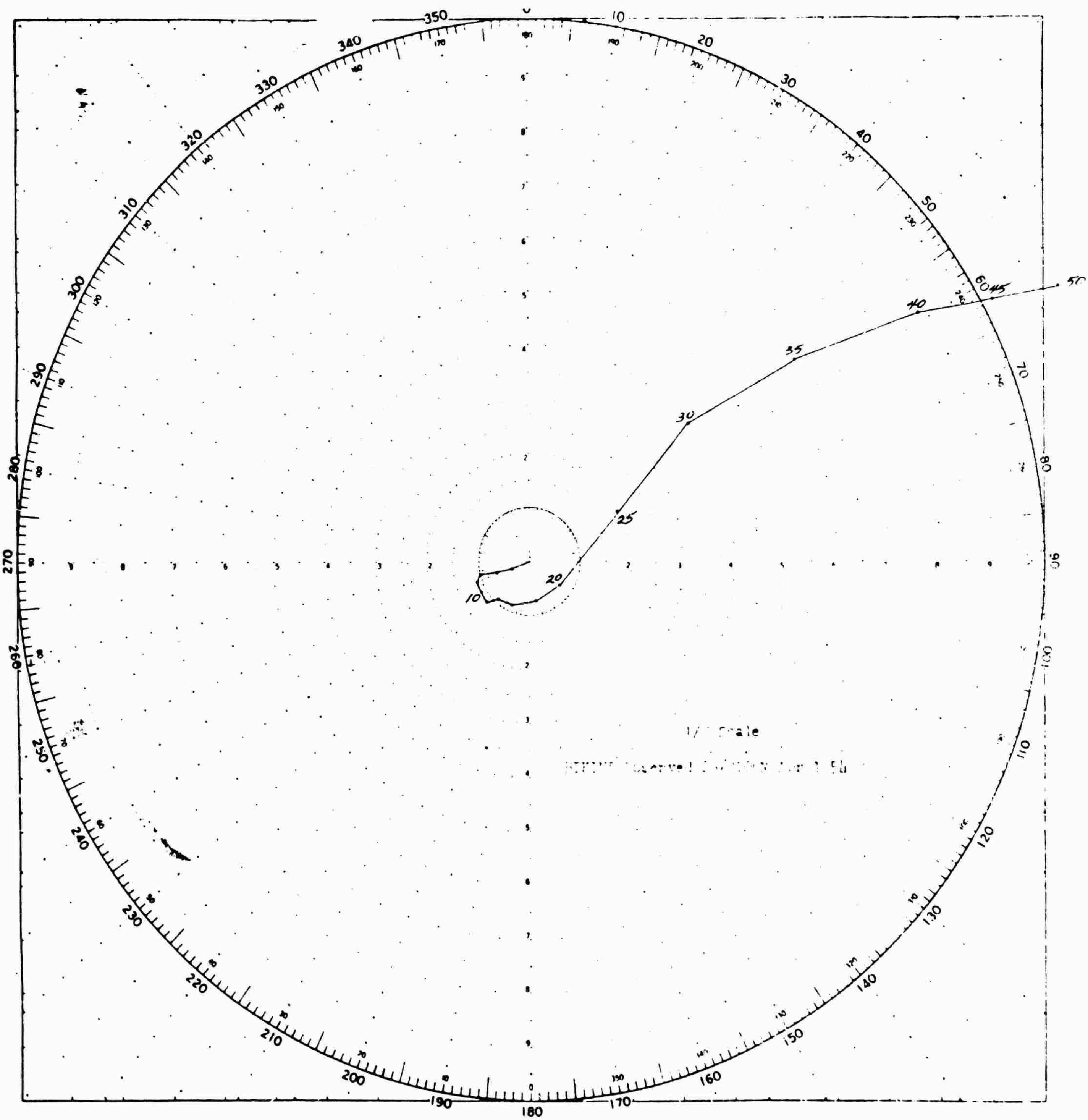

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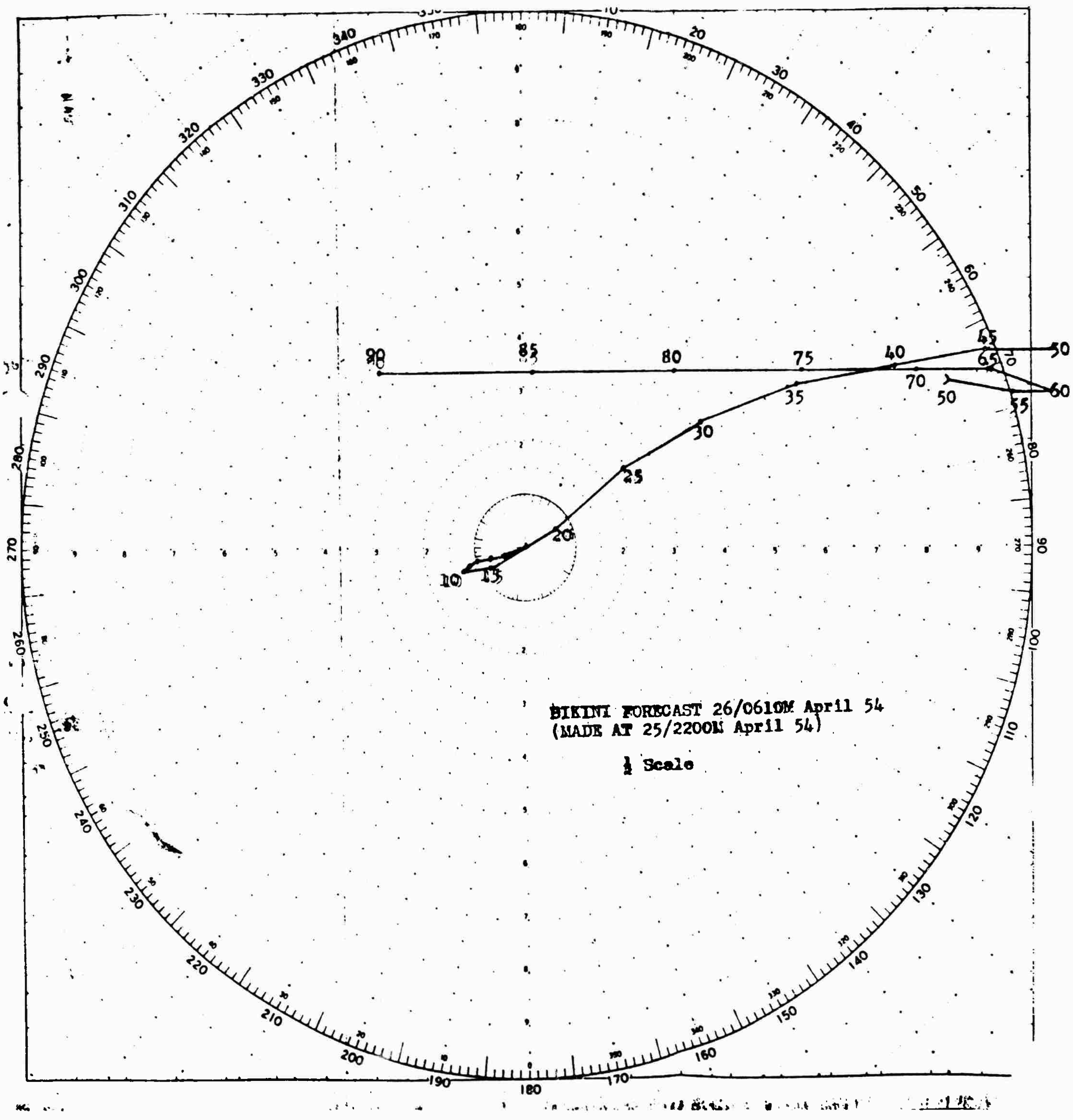
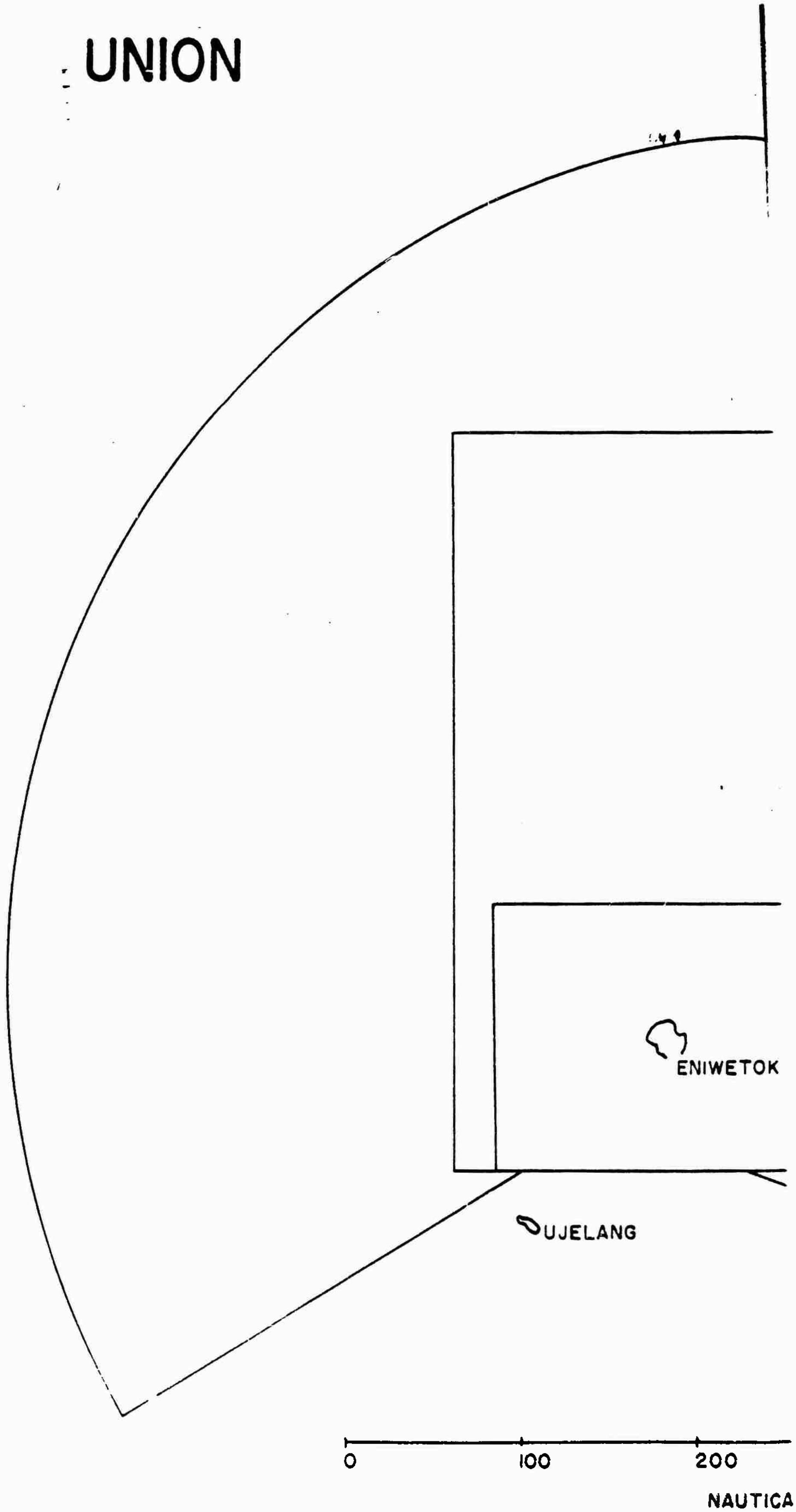
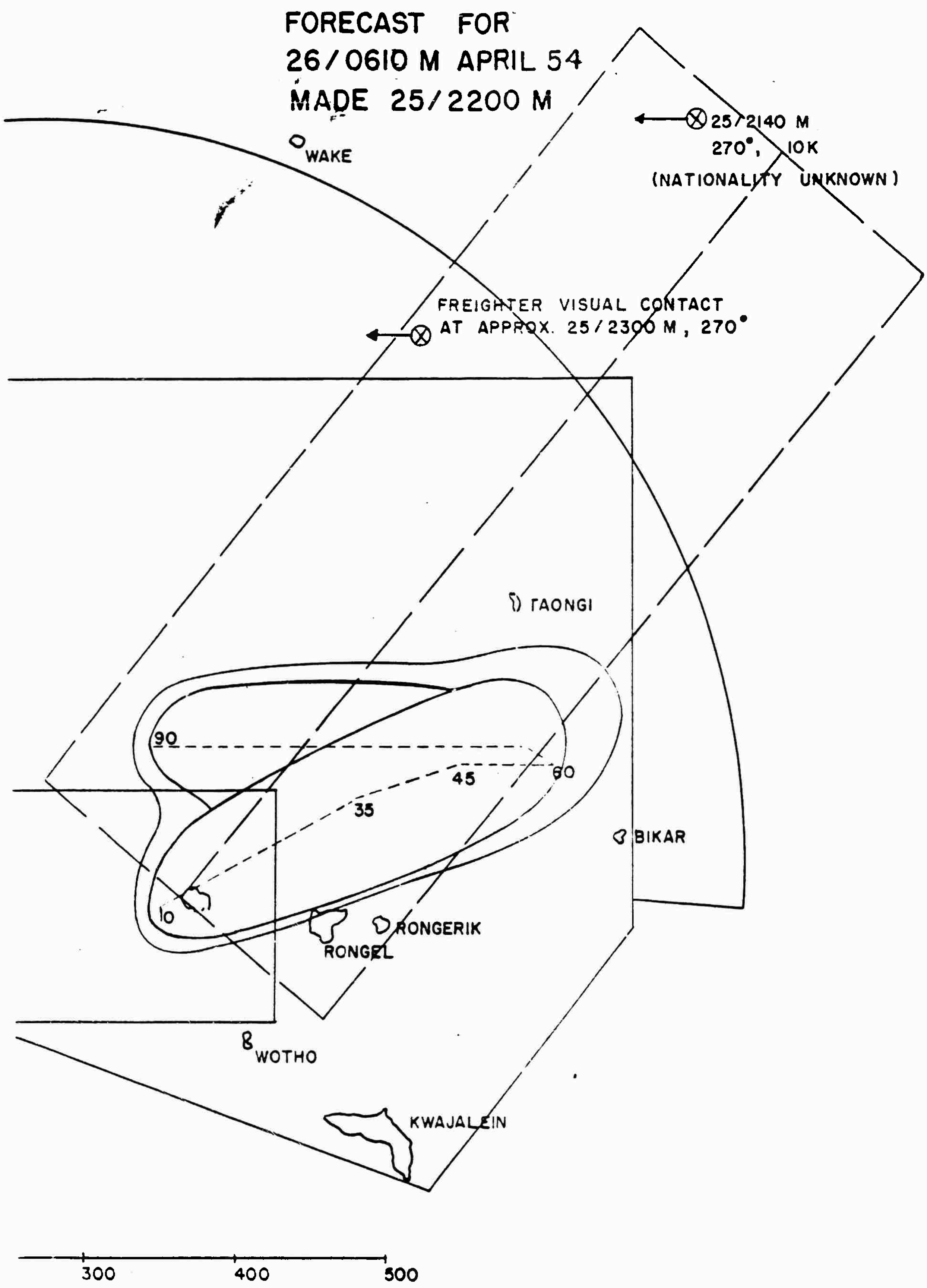
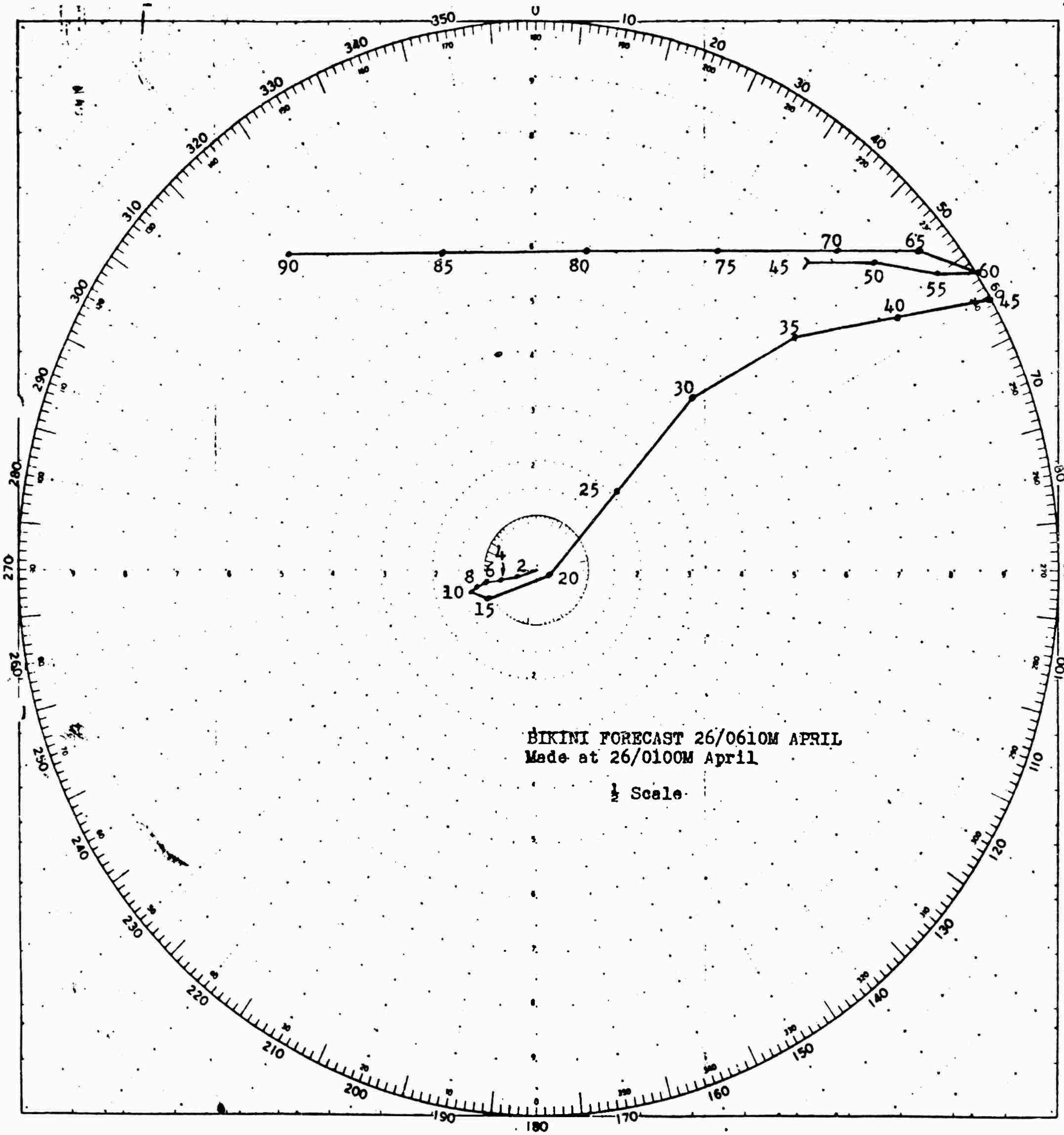

BIKINI FORECAST 26/0610M April 54
(MADE AT 25/2200M April 54)
½ Scale

UNION



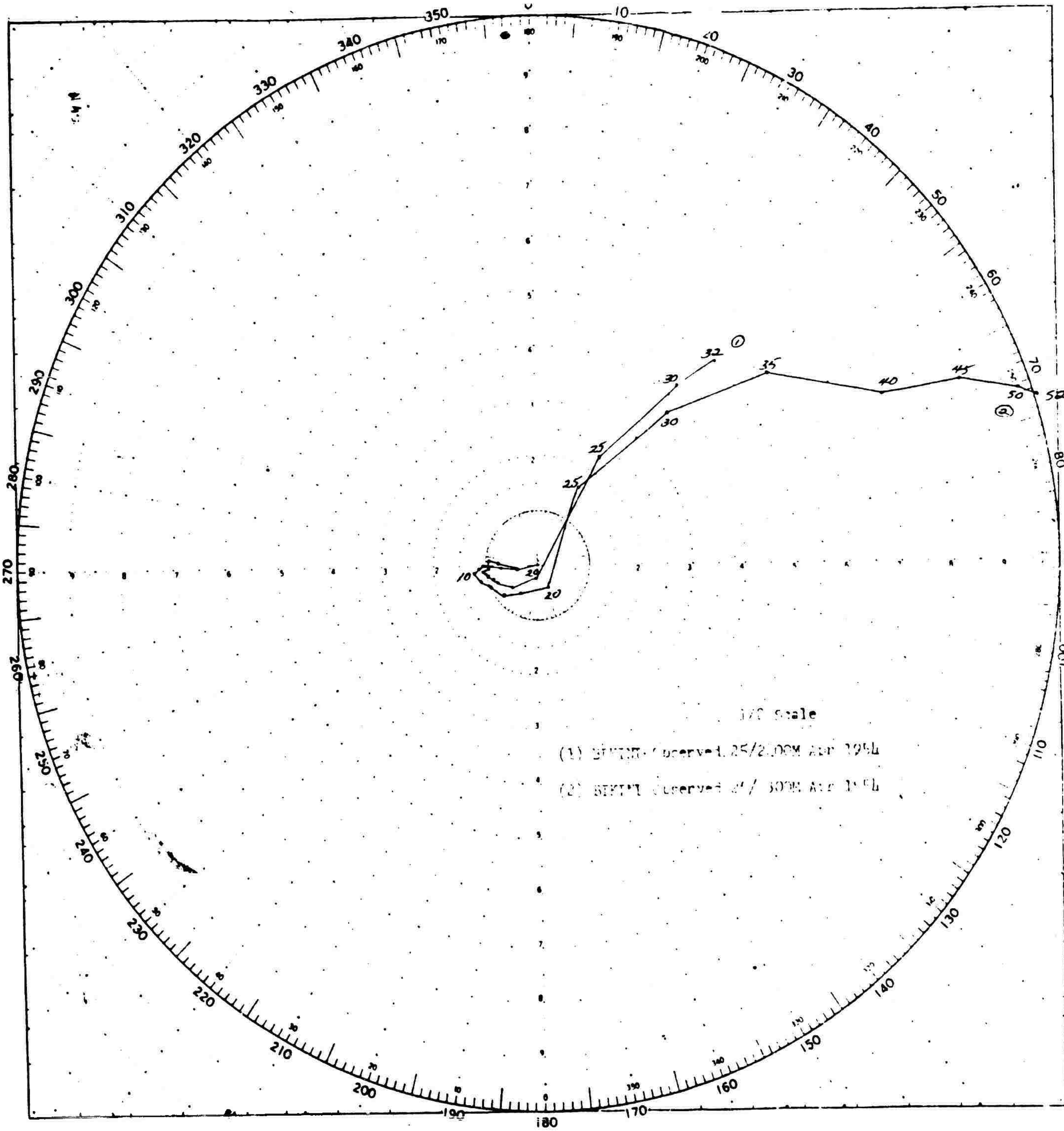
N-25


FORECAST FOR
26/0610 M APRIL 54
MADE 25/2200 M
25/2140 M
270°, 10K
(NATIONALITY UNKNOWN)
WAKE
FREIGHTER VISUAL CONTACT
AT APPROX. 25/2300 M, 270°
TAONGI
90
60
45
35
10
BIKAR
RONGERIK
RONGEL
WOTHO
KWAJALEIN
300
400
500
MILES



BIKINI FORECAST 26/0610M APRIL
Made at 26/0100M April

½ Scale



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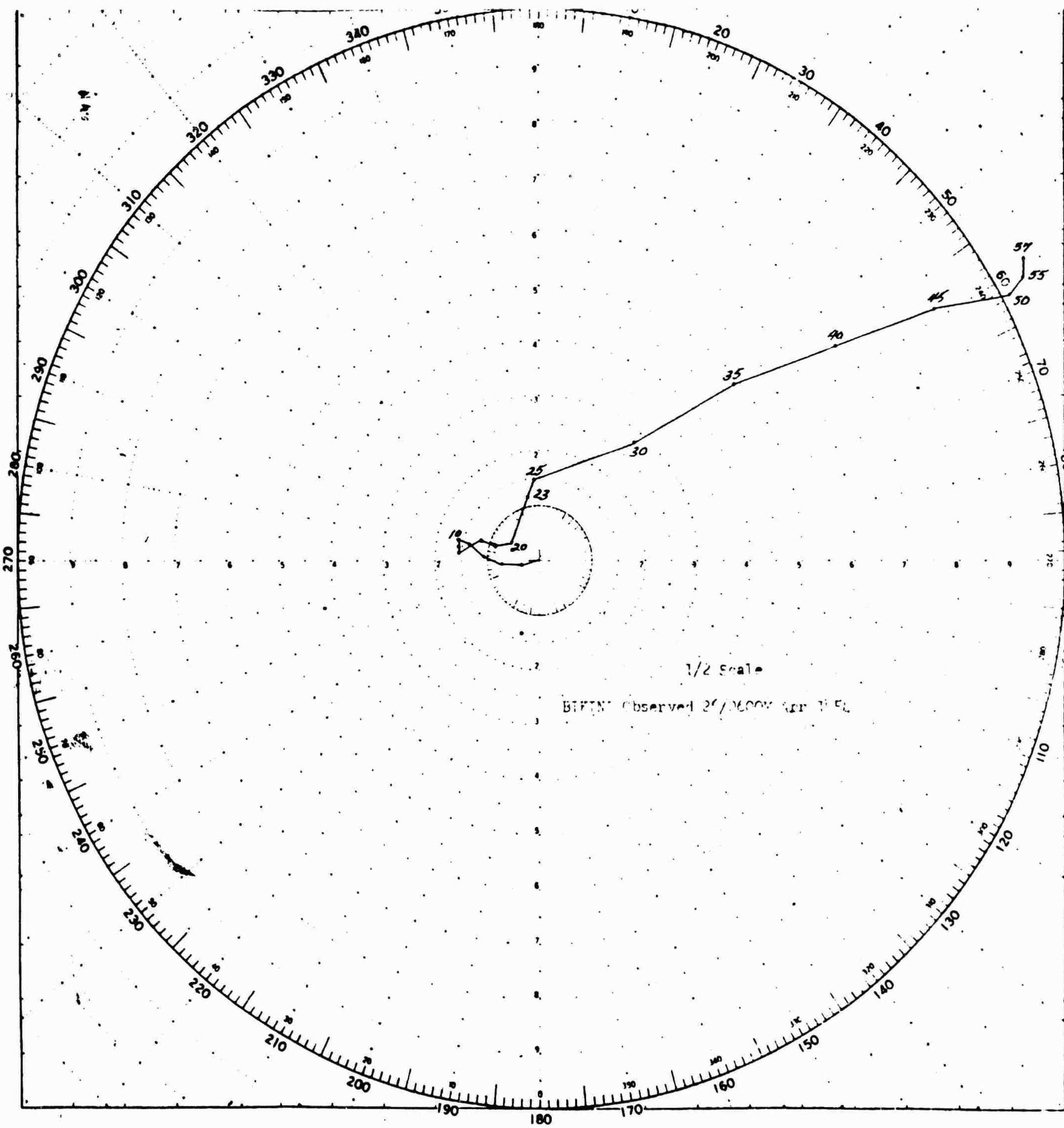
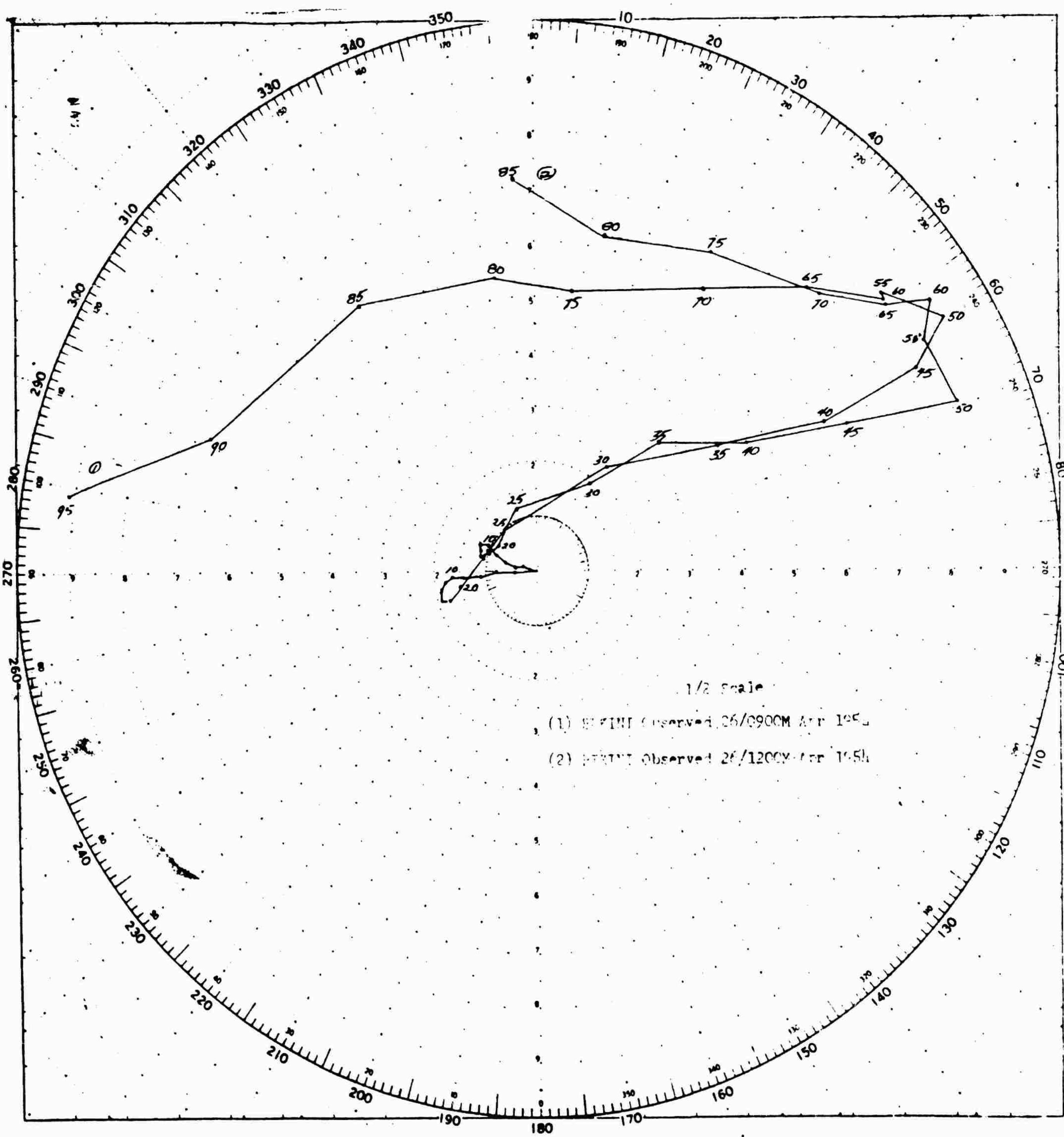
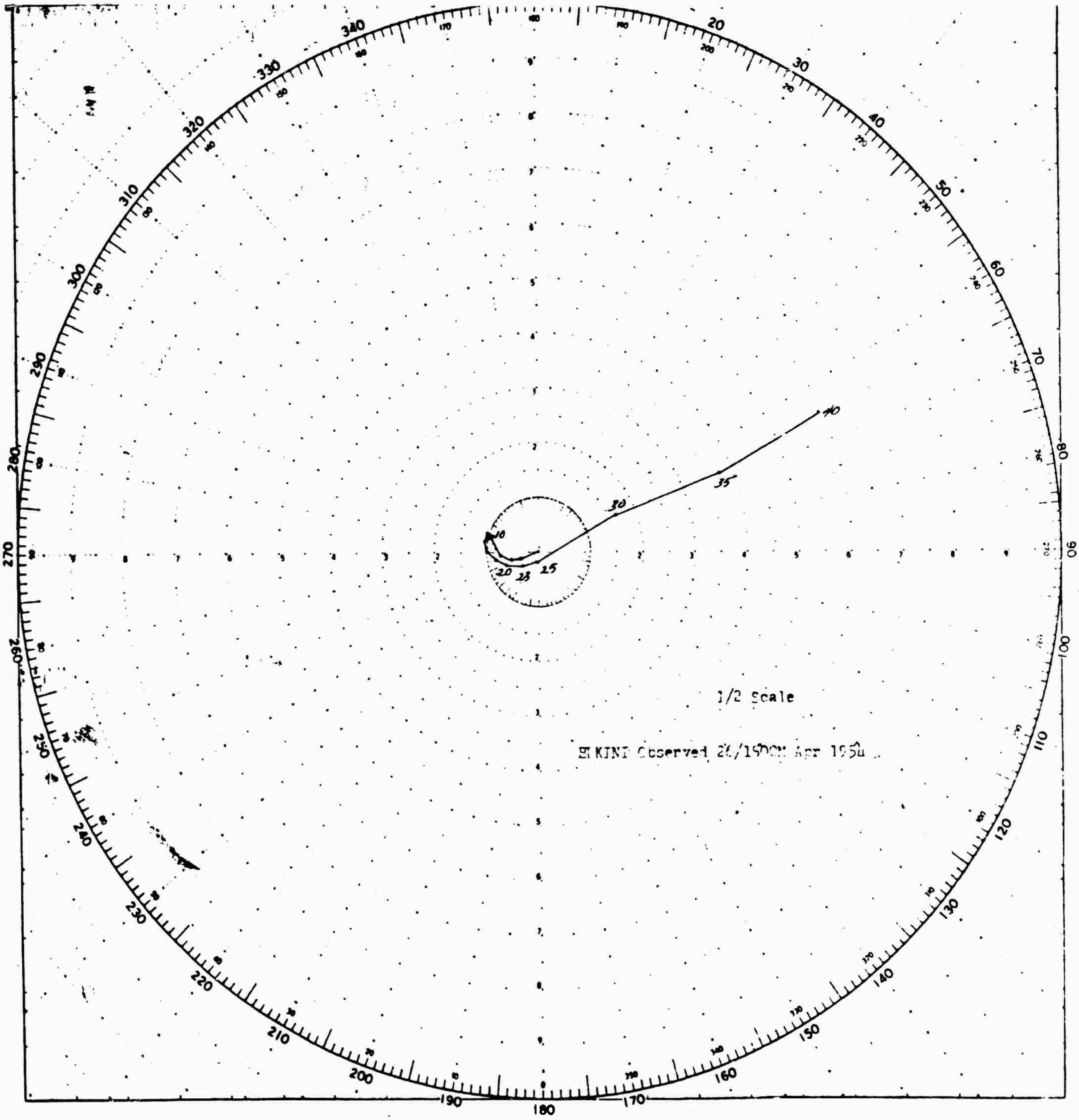
Scale


1/2 Scale


1/2 Scale
(1) Observed 26/0900M
(2) Observed 26/1200


1/2 Scale
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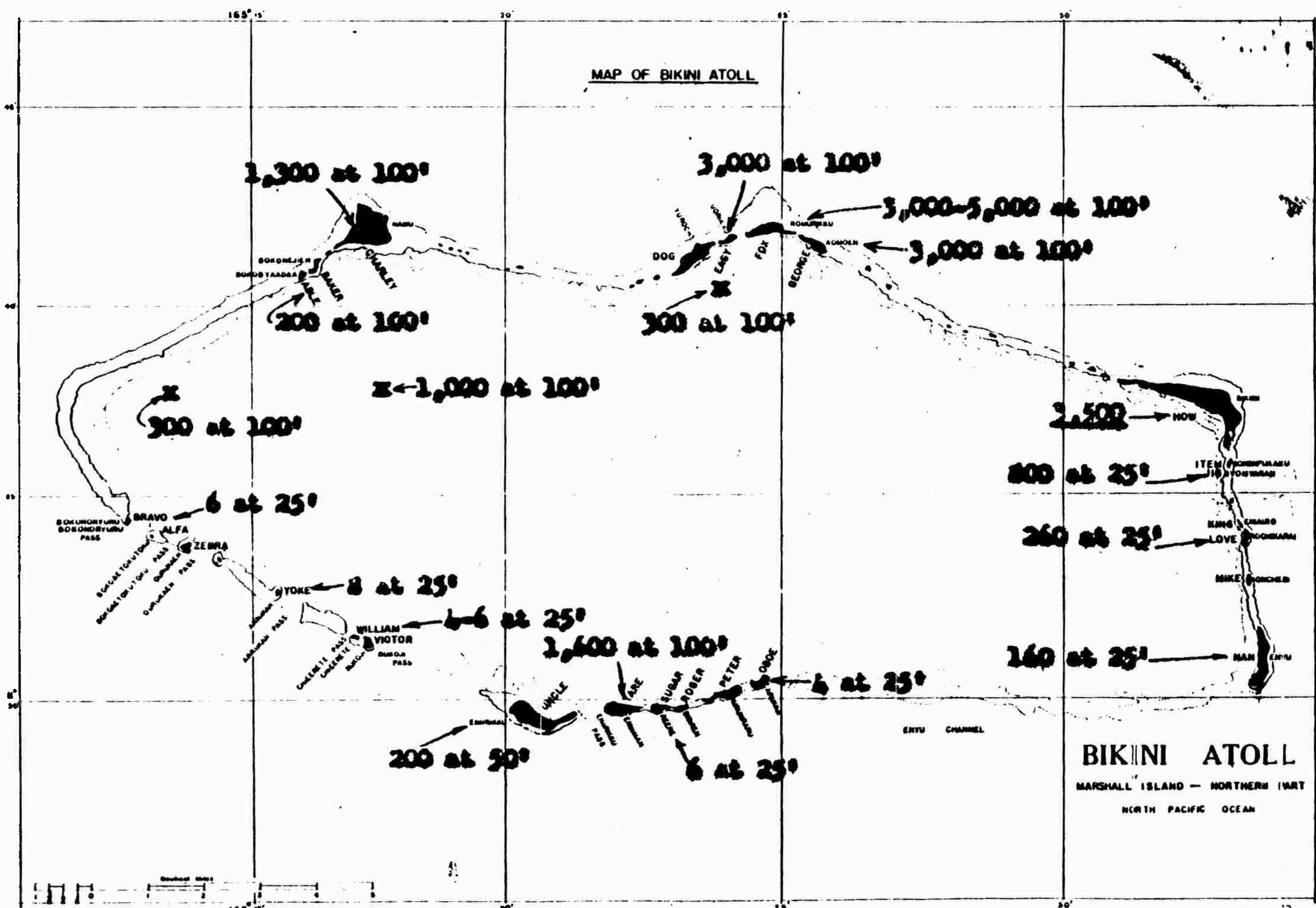
20
23
25
30
35
40



Radsafe Survey Readings UNION Day (approximately H+4 hrs)
(all readings in mr/hr; ground readings underlined)

AIR RAD SAFE OPERATIONS FOR UNION

1. SUMMARY:

The atomic device UNION of Operation CASTLE was detonated at 1810 hours Zebra 26 April 1954. The UNION cloud reached an altitude on the order of 95,000 feet. The Air Rad Safe operations in connection with this detonation were successfully conducted and resulted in much timely information on the Post-event conditions not only on the shot atoll of BIKINI but also the adjacent areas. Cloud tracking aircraft obtained data which indicated that the lowest section of the UNION cloud stem, up to perhaps fifteen thousand feet, was moving to the west-northwest at approximately fifteen knots. This movement, plus the moderate intensities encountered (a maximum of 60 Mr/Hr), established the fact that this portion of the cloud did not constitute a hazard to ENIWETOK ATOLL 186 miles to the west of BIKINI. Another aircraft made contact with fallout from the middle level (twenty to sixty thousand feet of the cloud. As had been forecast by the preshot studies, this level was proved to be moving to the east-northeast at fifteen knots. Because of the extreme height of the cloud, no contact was made with fallout from the top level of the cloud. From the meteorological data one would predict a movement to the north and to the west. On the basis of the foregoing it was apparent that there was no hazard to the populated atolls within or without the Pacific Proving Ground. This premise was verified when one of the cloud tracker aircraft was diverted for the purpose of making a minimum altitude radiological survey of all land masses which conceivably could have been affected by fallout of UNION debris. This hurried survey showed essentially no areas to have received fallout; a fact which was confirmed when a more leisurely and refined survey was possible. There was no evidence of significant fallout outside the Pacific Proving Ground.

2. GENERAL:

a. Sources of Information:

Cloud tracking information for UNION was available from five sources. The contribution of each of these sources, which are listed below, will be discussed in subsequent paragraphs.

Sampling Aircraft Reports
Sweet-Sour Reports
Special Cloud Tracking Flights
Weather Reconnaissance Flights
AFOAT-1 Flights

b. Overall Cloud Movement (within the PPG):

The BIKINI winds observed shortly after shot time are plotted in the hodographs. From the hodographs is can be seen that the UNION cloud, whose maximum height was of the order of 111,000 feet at 45 minutes, was subjected to three wind shears. The lowest level of the cloud (surface to fifteen thousand feet) was influenced by the winds from the east which aver-

Incl 6

aged fifteen knots. This movement was confirmed by a cloud tracking aircraft flying sixty miles west northwest of Ground Zero at eight thousand feet; the maximum intensity reported was 60 Mr/Hr. Based on the position of this contact and the forecast air trajectories, it is believed that this contamination subsequently passed to the north of ENIWETOK ATOLL. The middle level of the cloud (twenty to sixty thousand feet) moved to the east-northeast at a speed of approximately fifteen knots - the wind velocities having decreased after shot time. Only one contact (at plus five hours) was made with fallout from this level of the cloud (see Appendix I). The highest level of mushroom probably moved to the north and west but none of the tracking aircraft made contact with fallout from this portion of the cloud.

3. SAMPLING AIRCRAFT REPORTS:

As in the case of previous shots, these reports were recorded by Rad Safe personnel aboard the Command Ship from plus two to plus five hours. Reports from these aircraft provided the first data available on initial cloud movement and confirmed the accuracy of the forecast air radex (see Appendix II).

4. SWEET-SOUR REPORTS:

These reports were submitted by any aircraft encountering radioactive contamination and not reporting by other means. No such reports were received following UNION.

5. SPECIAL CLOUD TRACKING (WILSON) FLIGHTS:

a. The initial phases of the UNION cloud tracking effort duplicated those which were so successfully employed for previous CASTLE shots. Two WB-29's, WILSON TWO and WILSON THREE, were placed in a holding pattern fifty miles west of Ground Zero at plus two hours. As will be seen from Appendix I, the location and orientation of this pattern is such that any cloud segments moving toward either ENIWETOK or UJELANG should be intercepted by at least one of these aircraft. WILSON THREE initially flew in this pattern at six thousand feet but was subsequently ordered to eight thousand feet in order to maintain flight under visual conditions. WILSON TWO operated at ten thousand feet throughout his mission.

b. At approximately 2130 Zebra Wilson was requested to descend to one thousand feet and make a survey of the southern islands of BIKINI ATOLL and the airstrip in particular. This effort proved that there were no portions of GILDA (the atomic cloud or its fallout) endangering either the fleet or the southern islands. The airstrip was found to have been flooded and littered with debris but the radiation reading at one thousand feet was only 6 Mr/Hr. On the basis of this information it was determined that it was safe for the fleet to approach the atoll and to begin the helicopter phases of the detailed Rad Safe survey, WILSON THREE returned to the racetrack and resumed orbiting at eight thousand feet; the increase in altitude was authorized in order that the flight could be conducted under visual conditions. At 2323 Zebra WILSON THREE made the first contact with the westward moving portions of GILDA while flying at he north end of the racetrack pattern; see Appendix L. The maximum intensity of 60 Mr/Hr was reported at 2340 Zebra but contacts continued to be made in the same general area until 0117 Zebra. It is interesting to note that all fallout was encountered at the northern end of the pattern, an excellent verification of the path forecast by the air particle trajectories. Later during UNION day it became obvious that the wind patterns were relatively unstable and that there was a slight possibility that fallout may have occurred in the vicinity of the populated atolls to the southeast of Ground Zero. To evaluate this possibility, WILSON THREE was directed at 0200 Zebra to conduct an area search along a true bearing of 100 degrees from Ground Zero at an altitude of one thousand feet. In addition, a survey of each atoll in this region was to be conducted at minimum altitude. Enroute to the designated sector WILSON THREE passed almost directly over Ground Zero. Gamma radiation or "shine" from the crater is, without a doubt, the cause for the very hight readings reported at 0230 and 0232 Zebra (1000 and 2000 Mr/Hr respectively). In this case the aircraft background remained at 5 Mr/Hr. This is in direct contrast to the experience of the WILSON TWO flight which encountered fallout measuring 2000 Mr/Hr where the subsequent aircraft background was 250 Mr/Hr. The results of the atoll survey are tabulated in Appendix I (atoll locations can be determined by comparing the time of survey with the position plot). It can be seen that RONGELAP, RONGERIK and TAKA ATOLLS appeared to have received very slight fallout, probably very few Mr/Hr. The readings at the other atolls were undoubtedly aircraft background. A more comprehensive survey conducted for the NYKOPO on UNION plus one day confirmed the validity of the WILSON THREE survey. The only other GILDA contact reported by this aircraft was at 0845 Zebra, fifty miles west-southwest of Ground Zero. This was undoubtedly fallout from a level of the cloud that initially moved east and then was carried back by the "easterlies" prevailing at the lower altitudes.

c. WILSON TWO, flying at ten thousand feet, made no contamination contacts in the racetrack pattern between plus two and plus five hours which indicates that the upper limit of the westwar-moving cloud was about ten to fifteen thousand feet. Later, while carrying out the area search (between 65 and 95 degrees from Ground Zero, this aircraft made its first interception of GILDA, eighty-five miles east-northeast of BIKINI ATOLL. The radiac instruments soon (2334 Zebra) indicated a maximum reading of 2 R/Hr; contamination which obviously must have been fallout from the wenty, thirty, and forty thousand foot levels (See Trajectories). This penetration left the aircraft with a background of approximately 250 Mr/Hr. Subsequent reports by this aircraft probably reflect no new contacts but rather the decay of the residual contamination.

d. WILSON FOUR departed ENIWETOK ISLAND at approximately UNION plus twelve hours with the mission of conducting an area search out to maximum range between 65 and 95 degrees true from Ground Zero at an altitude of ten thousand feet. At plus fifteen hours this aircraft was directed to divert for the purpose of making a minimum altitude survey of UTHO ATOLL, the only populated atoll for which a potential hazard existed and which had not been surveyed by WILSON THREE. This survey, as one would suspect, showed no contamination at that point. WILSON FOUR resumed search in his previously designated area with negative results. This was somewhat surprising since one would have expected this aircraft to contact the southern edge of the fallout from the twenty to forty thousand foot levels. Thus it appeared the debris took a somewhat more northerly course than was forecast.

e. Subsequent WILSON flights for UNION were cancelled.

6. WEATHER RECONNAISSANCE FLIGHTS:

Three weather reconnaissance flights were flown on UNION plus one day. These flights to the west, south, and the northeast were negative except for a 1 Mr/Hr contact 800 miles to the northeast of Ground Zero at plus thirty-three hours.

7. AFOAT-1 FLIGHTS:

AFOAT-1 sponsored flights made radioactive sample collections of UNION debris at several remote locations. In all cases the debris was found to be widely dispersed throughout the general area but, as one would expect, the levels were quite low ranging from a few Mr/Hr to a small fraction of that amount. The results of these collections are tabulated below.

ZEBRA TIME	POSITION	ALTITUDE	COUNTS/MIN/Hr (in millions)
27/2000 - 27/2200 (plus 50-60 hours)	20N 162W to 21N 158W (300 Mi south Hawaii)	11,000	1.7
28/0930 - 28/1330 (plus 65-69 hours)	22N 156W to 23N 154W (250 Mi north Hawaii	15,000	2.4
28/2030 - 29/0200 (plus 74-79 Hours)	22N 152W to 27N 152W (250 Mi northeast Hawaii	16,000	0.7
02/2100 - 02/2240 (plus 7 days)	23N 116W to 23N 117W (600 Mi south San Diego)	18,000	1.0

9. CONCLUSIONS:

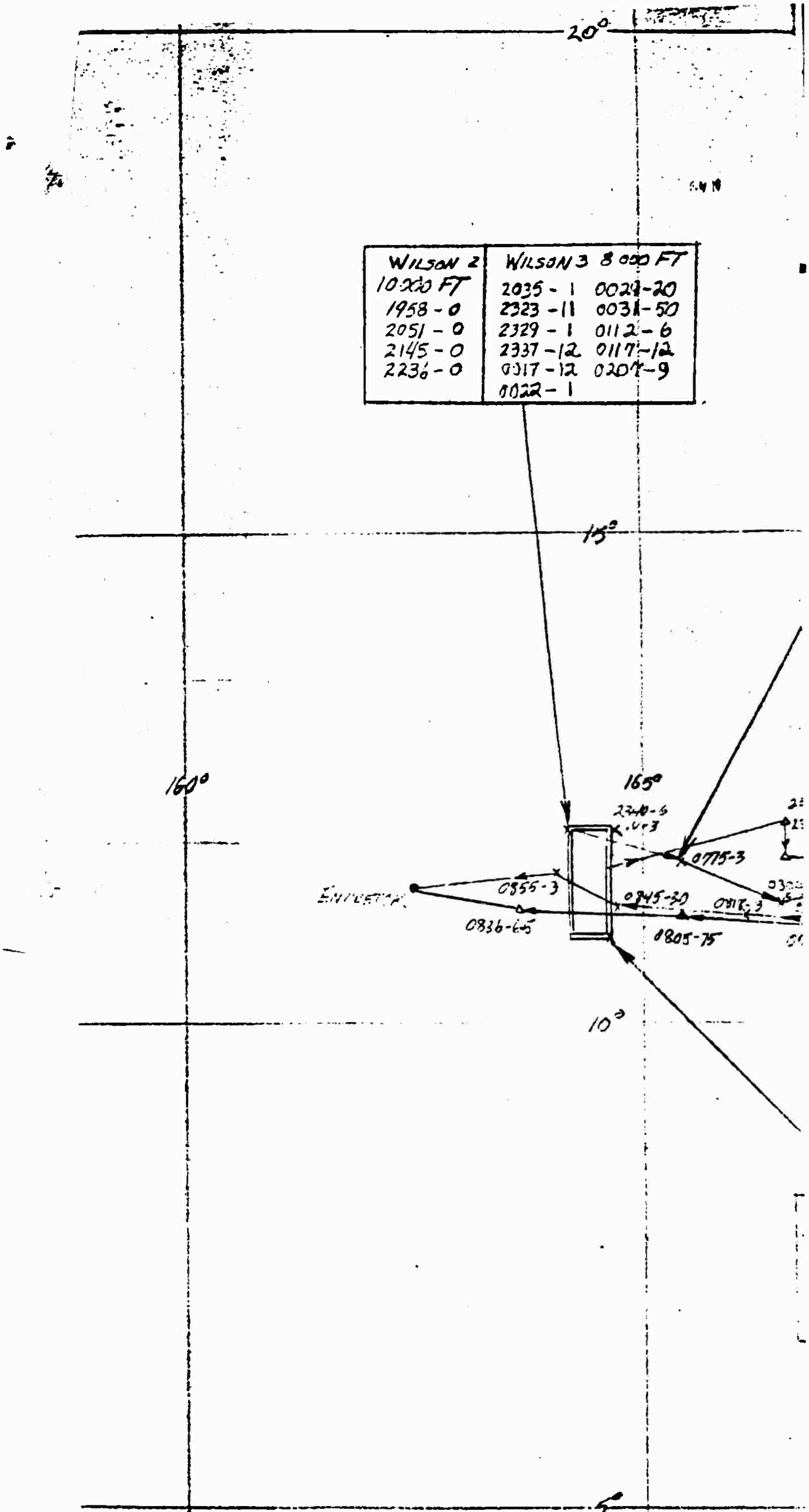
a. The Air Rad Safe operations for UNION were quite successful. In particular, the cloud tracking operations early established the fact that there were no elements of the UNION cloud or fallout which necessitated the evacuation of nearby atolls.

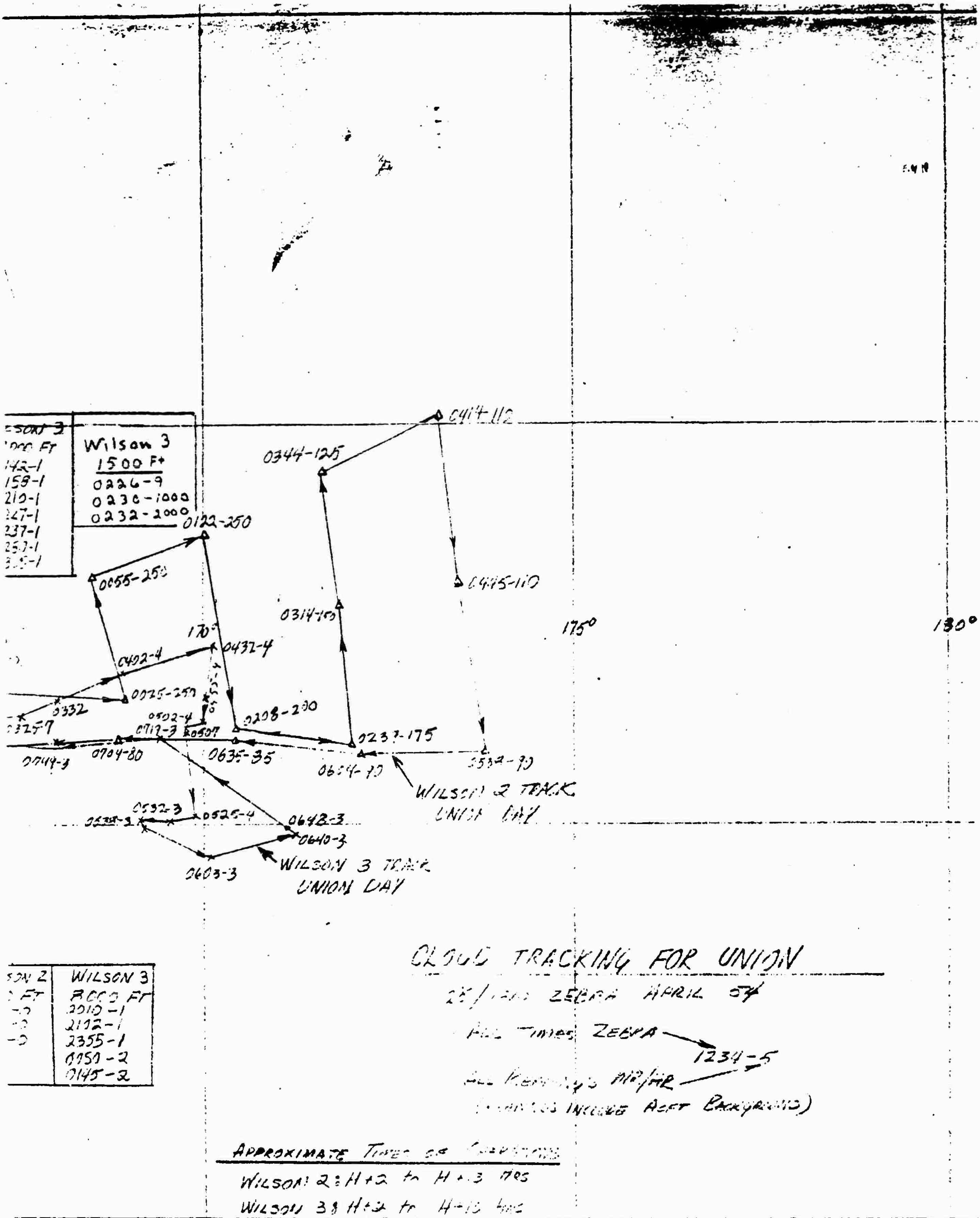
b. The use of the WB-29 WILSON cloud tracking aircraft as a means for making a preliminary survey of the populated atolls to the southeast of Ground Zero proved practical. These aircraft provided the Task Force Commander with information he required on shot day and which was available from no other source.

c. No hazardous fallout appeared likely outside the immediate area of Ground Zero and the adjacent downwind areas. Fallout outside the PPG was forecast to be slight and of no consequence from the health standpoint.

10. RECOMMENDATIONS:

On the basis of their performance for this and preceding events, the crews of the WILSON aircraft should be complimented upon the diligence and the ingenuity with which their missions were accomplished. Their effectiveness, often under unusual and somewhat hazardous circumstances, reflects great credit upon themselves, their unit, and its supervisory personnel.

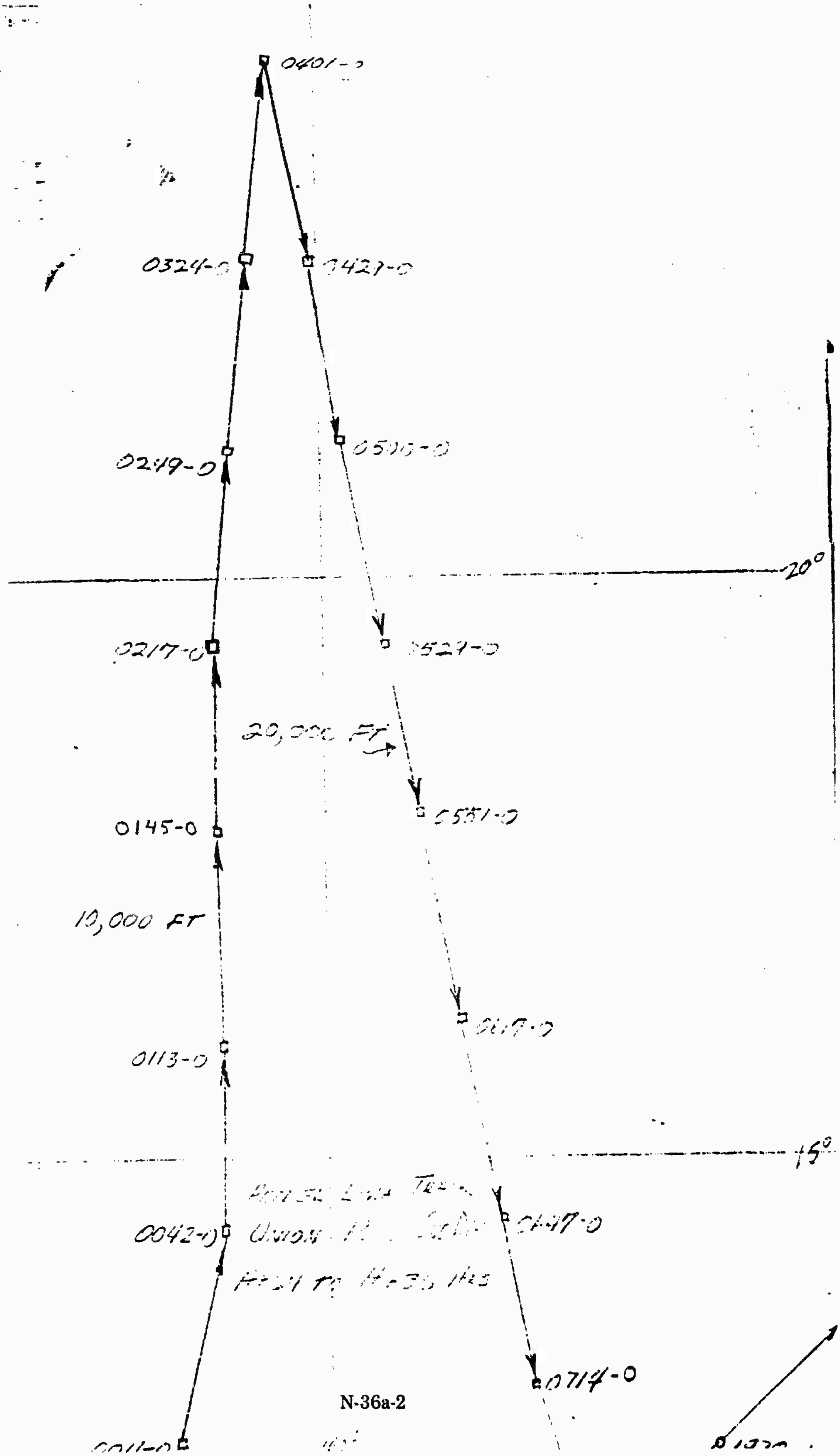

20°
WILSON 2
10,000 FT
1958 - 0
2051 - 0
2145 - 0
2236 - 0
WILSON 3 8,000 FT
2035 - 1
2323 - 11
2329 - 1
2337 - 12
0017 - 12
0022 - 1
0029 - 20
0031 - 50
0112 - 6
0117 - 12
0207 - 9
15°
160°
165°
0715-3
0855-3
0845-30
0836-65
0805-75
10°
5°



N-36a-1

UNION DAY ATOLL SURVEY BY WILSON 3 & 4

ATOLL	TIME	READING	ALTITUDE
AILINGINAE	0300 Z	5 MR/HR	300 Feet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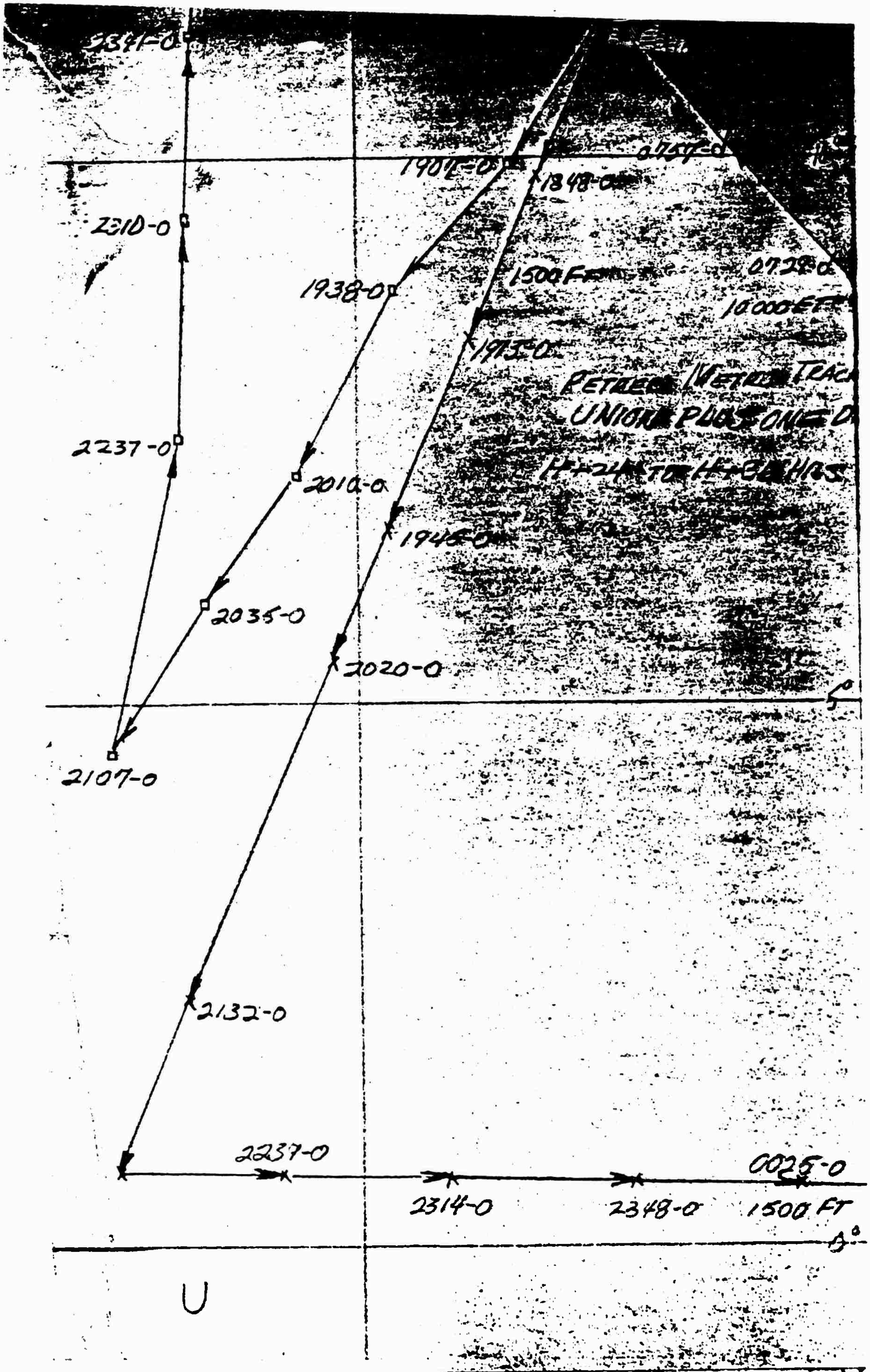
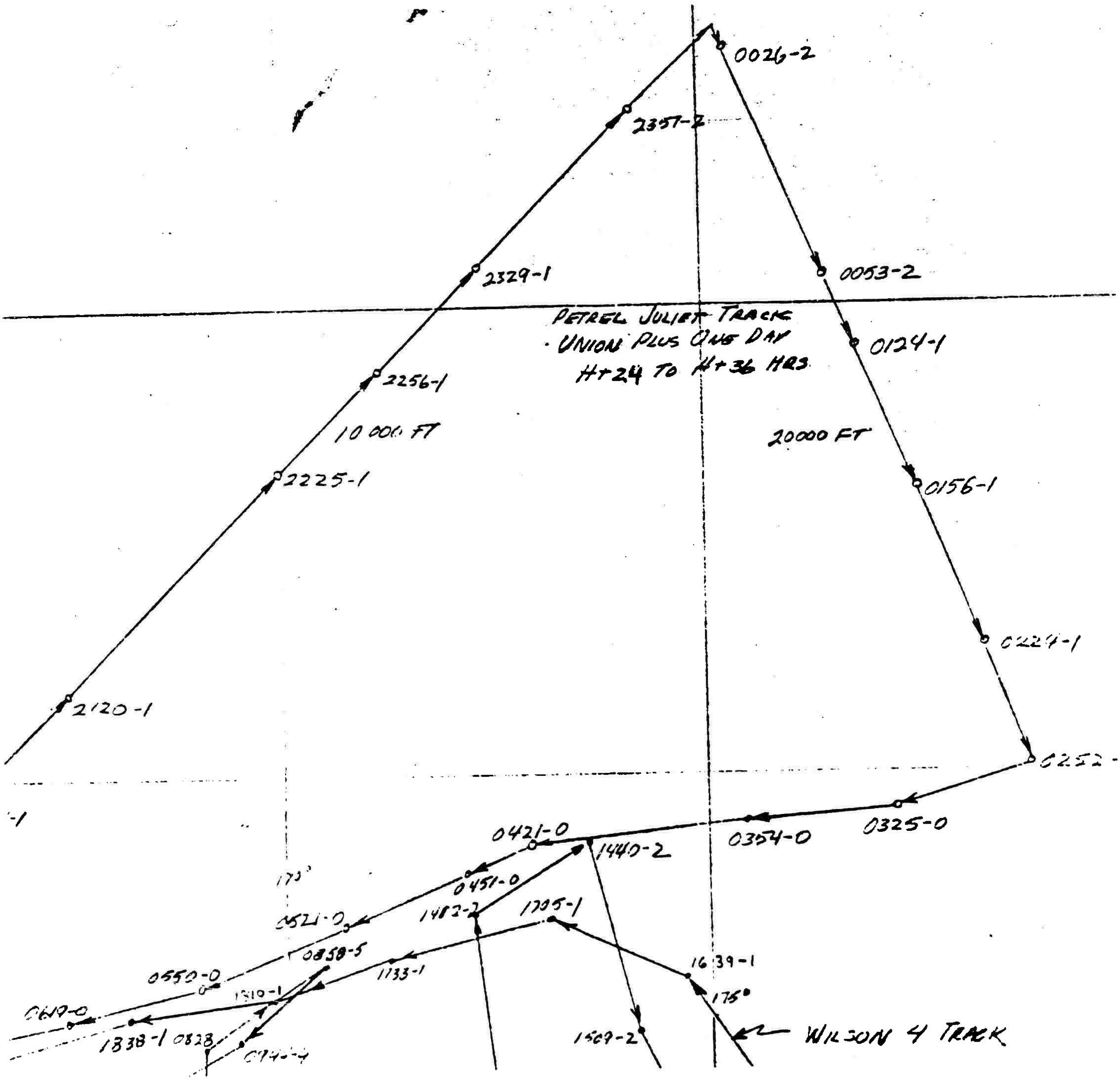
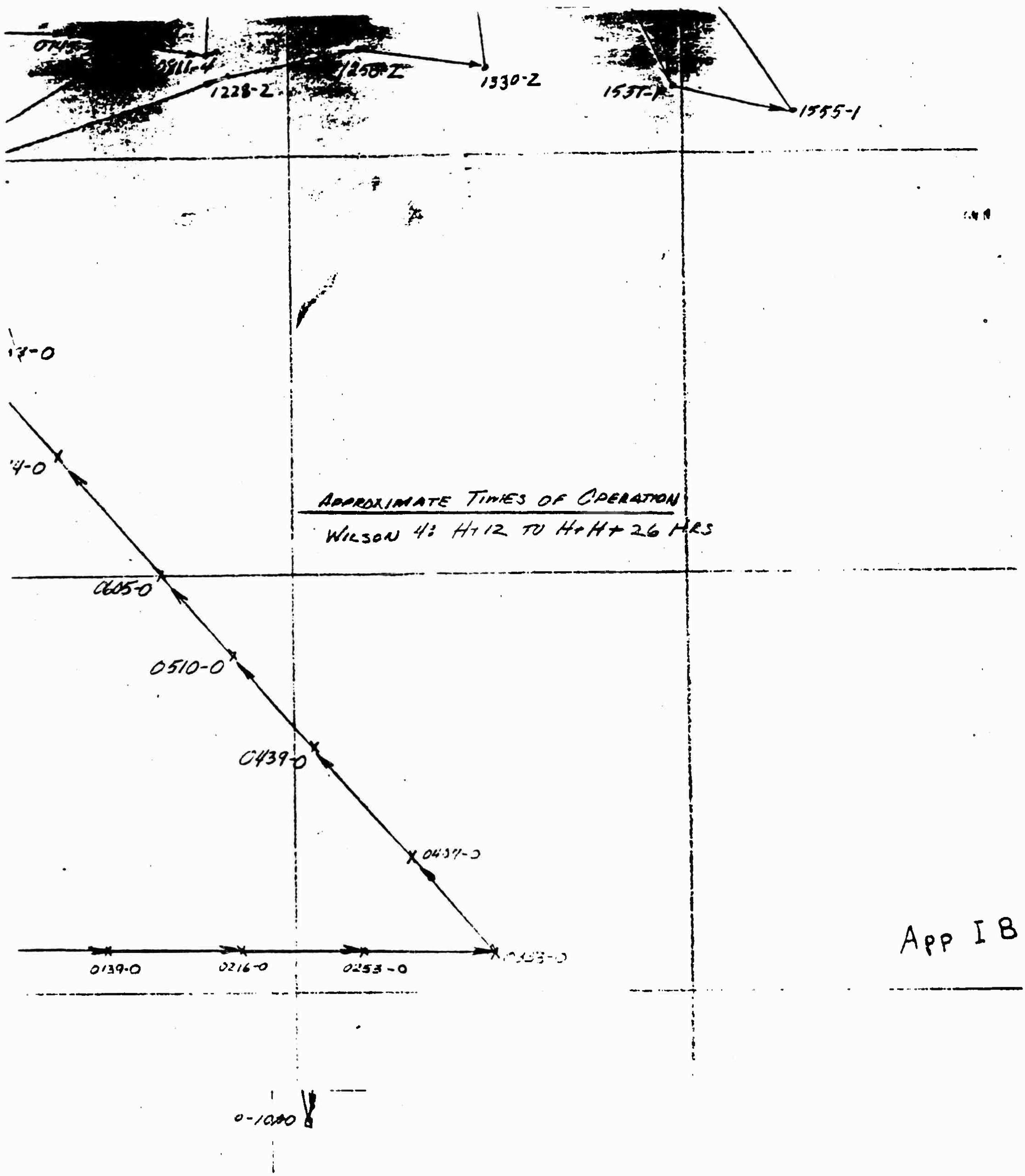
0427-0
0249-0
20°
0217-0
20,000 FT
0145-0
0551-0
10,000 FT
0113-0
15°
0042-0
0647-0
0714-0
0011-0



2341-0
1902-0
0757-0
1848-0
2310-0
1938-0
1500 FT
0728-0
10,000 FT
1951-0
2237-0
2010-0
1946-0
2035-0
2020-0
2107-0
2132-0
2237-0
0025-0
2314-0
2348-0
1500 FT
U


PETREL JULIET TRACK
UNION PLUS ONE DAY
H+24 TO H+36 HRS
0026-2
2357-2
0053-2
2329-1
0124-1
2256-1
10 000 FT
20000 FT
2225-1
0156-1
2120-1
0252-1
0325-0
0354-0
0421-0
1440-2
0451-0
1482-2
1705-1
0521-0
0858-5
1133-1
1639-1
0550-0
175°
1838-1
1509-2
WILSON 4 TRACK

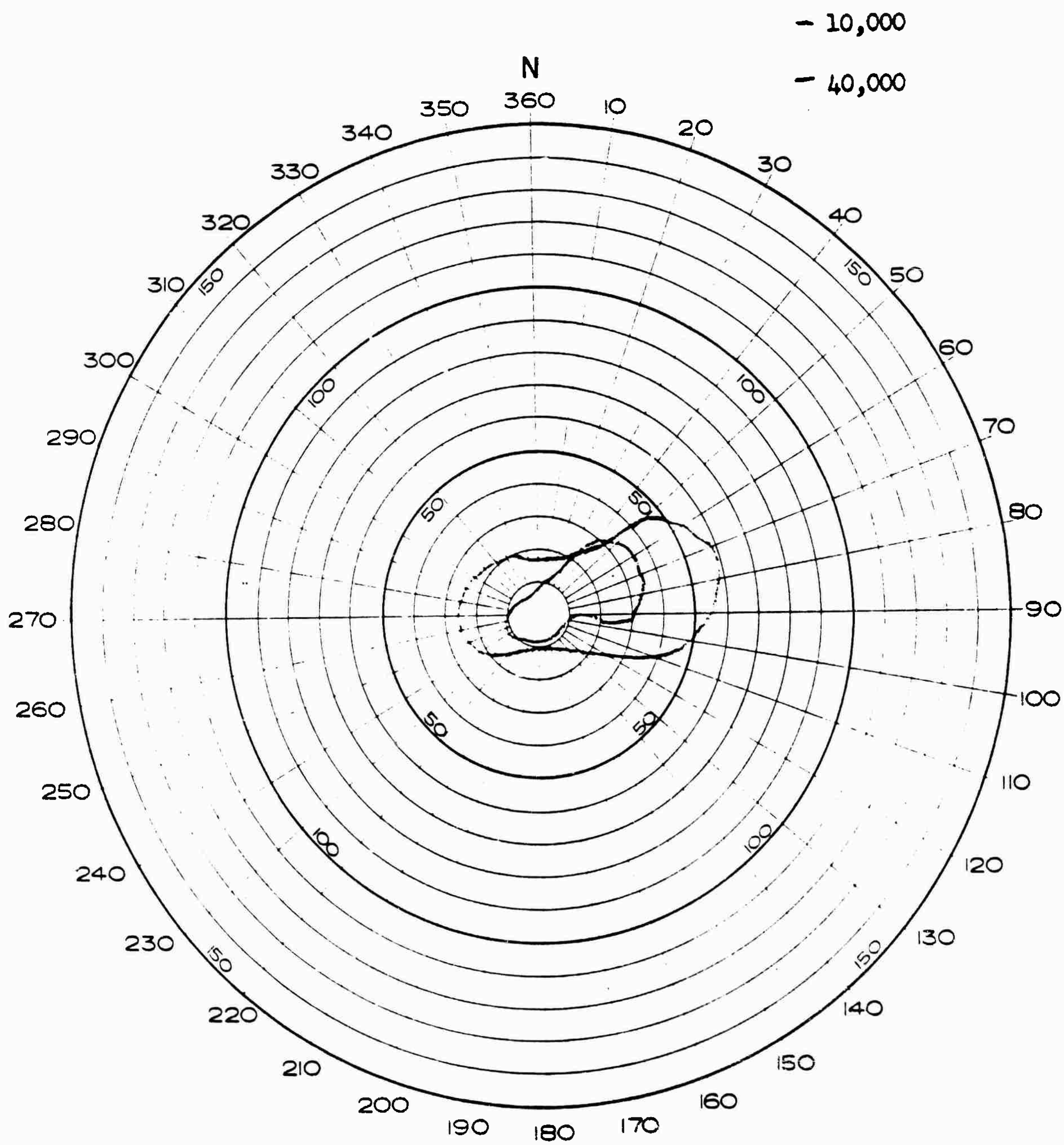


1228-Z
1250-Z
1330-Z
1555-1
APPROXIMATE TIMES OF OPERATION
WILSON 4: H+12 TO H+H+26 HRS
0605-0
0510-0
0439-0
0139-0
0216-0
0253-0
0-1000

App I B

HODOGRAPH

RESULTANT WINDS AND SURFACE RADEX



UNION AIR RADEX FOR UNION PLUS ONE HOUR

N-36c

Preliminary Results

NYKOPO Airborne Monitoring Survey Flights o/a 25 April 1954 (conducted by Health and Safety Laboratory, New York Operations Office, AEC.).

Location (Atoll unless otherwise indicated)	Local Time (April)	Maximum Ground Reading (in mr/hr)	Local Time (April)	Maximum Ground Reading (in mr/hr)	Local Time (May)	Maximum Ground Reading (in mr/hr)
KWAJALEIN	211435	0	271510	0	011200	0.1 *
LAE	210824	0.3	270853	0	010655	0.04
UJAE	210834	0	270903	0.2	010707	0.08
WHOTHO	210901	0	270930	0	010737	0.3
AILINGINAE	210952	2.4	271029	1.6	010830	0.04
RONGELAP ISLAND	211006	12	271041	8.0	010895	20
RONGERIK	211020	8.0	271055	11	010858	8.0
TAONGI	211145	0.04	271223	0.2	011014	0.04
BIKAR	211241	0.4	271318	0	011111	3.7
UTIRIK	211259	0.8	271335	2.0	011135	1.7
TAKA	211304	0.4	271342	2.4	011138	0.7
AILUK	211323	0.1	271402	0.4	011159	0.6
JEMO	211332	0.08	271410	0	011209	0.12
LIKIEP	211343	0.04	271422	0.6	011216	0.08

* Ground Observation.

Maximum Ground Readings Other NYKOPO Flights (in mr/hr)

Flight BAKER (21 April) 0.4
Flight BAKER (2 May) 0.12
Flight CHARLIE (2 May) 0.07

Incl: 7

SUMMARY OF THE STATUS OF TRANSIENT SHIPPING IN THE PPG AREA O/A 26 APRIL 1954

1. Task Force sources of information:

   a. USS BARIBAULT, Kwajalein on 22 April

   b. USS WANDANK, ATA-204, 11-07N, 175-19E course 76°, SOA 6.7 knots at 251200M

   c. USS LEO, AKA-60, at Eniwetok at 251200M through 271200M

   d. PC-1546 departed Rongerik 261330M to 10-27N, 167-27E, SOA 18 knots, thence to Bikini via route points 10-22N, 166-56E and 10-32N, 166-04E, SOA 12 knots, ETA Bikini 270500M.

   e. USNS PVT T. S. MERRELL, 21-26N, 168-40E course 260, SOA 16.5 knots at 271200M.

   f. USNS GEN M. M. PATRICK, 7-39N, 156-20E, course 269, SOA 14.9 knots.

   g. USS LST 762, ETD Eniwetok 271300M, to 10-45N, 163-00E, SOA 5 knots.

   h. Visual contact by search aircraft, Freighter at 1712N, 167-40E, course 270 SOA 10 knots at 252300M.

   i. Radar contact by search aircraft, fishing boat at 19-33N, 171-00E, course 270, SOA 10 knots, nationality doubtful.

2. COMNAVFORMARIANAS source of information:

   a. M/V Roque departed Ponape 25 April. 261200M position 8-18N, 155-27E.

Incl: 8

YANKEE

Following UNION, several attempts were made to fire the ENIWETOK shot (NECTAR); however, no favorable wind pattern materialized. Although patterns with some southerly components were obtained, the southerly winds were not considered sufficiently deep or strong. Forecast fall-out plots based on these patterns were such that there was a fair amount of risk that a significant part of the fall-out pattern would not lay far enough north of ground zero and would possibly over-lap the camp sites on PARRY and ENIWETOK Islands. At the 0030M command briefing, 4 May 1954 (for NECTAR), it was decided that the forecast conditions were too risky for the ENIWETOK shot, but that a similar pattern forecast to persist at BIKINI throughout the fourth and fifth of May was acceptable for YANKEE at BIKINI. Consequently, plans were made to shift operations to BIKINI provided a later check on the winds on the morning of 4 May indicated persistence or improvement of the wind pattern.

The winds being favorable, an informal command briefing was given approximately 1100M at the PARRY headquarters and shot advisories were issued to the appropriate internal and external commands. The search of Area GREEN was ordered to begin in the afternoon. A post-shot sector search (240 NM wide) out to 600 NM on true bearing 50° from GZ was ordered for take-off at 050615M. No fall-out was forecast for populated atolls or outside Area GREEN and no closure of air routes was recommended. No known transient shipping was within the 450 NM Danger Area.

Following move of the appropriate members of the headquarters and task group staffs to BIKINI by air and water, the formal pre-shot schedule of events began. The surface and air RADEXES were issued at approximately 1700M as follows:

Surface RADEX: True bearings from GZ 240° clockwise to 90° radial distance 60 NM for H to H plus 6 hours, plus a circular RADEX around GZ of 15 NM radius.

Air RADEX: H plus 1 hour, 10,000 feet and up (true bearings from GZ

225°	clockwise to	290°	maximum distance	25 NM
290°	clockwise to	30°	maximum distance	20 NM
30°	clockwise to	100°	maximum distance	30 NM
100°	clockwise to	225°	maximum distance	5 NM

40,000 feet and up (true bearings from GZ):

230°	clockwise to	320°	maximum distance	30 NM
320°	clockwise to	50°	maximum distance	15 NM
50°	clockwise to	115°	maximum distance	55 NM
115°	clockwise to	230°	maximum distance	15 NM

H plus 6 [illegible] up (true bearings from GZ):

245° clockwise to 2[illegible] maximum distance 110 NM
290° clockwise to 30° maximum distance 75 NM
30° clockwise to 85° maximum distance 130 NM

40,000 feet and up (true bearings from GZ):

230° clockwise to 320° maximum distance 110 NM
50° clockwise to 115° maximum distance 250 NM

A command briefing was held approximately 1830M to confirm previous decisions. The briefing consisted primarily of a look at the weather and wind patterns since the morning briefing and the forecast for shot time. A complete Command Briefing was given at midnight (050000M). The winds and weather being favorable, it was decided to continue with the shot and to look at the forecast and observed winds again at 0430M for a final firm decision. The forecast fall-out plot by elliptical approximation is included in Inclosure 4. The new technique, based on forecast time and space changes in the wind pattern for H to H plus 24 hours, gave a similar fall-out pattern except that its major axis lay more along an east to east-northeast line from GZ than northeast as given by the above plot. Due to significant changes in the forecast 72-hour air particle trajectories, a modified advisory was issued to CINCPACFLT revising the ten, twenty, thirty and fifty thousand foot levels. Due to a major shift in the 10,000 foot trajectory it was decided to recommend closure of the KWAJALEIN-GUAM air route from H plus 9 to H plus 24 hours. This was subsequently accomplished by CINCPACFLT. A modified surface RADEX was issued as follows:

Surface RADEX (true bearings from GZ for H to H plus 6 hours):

320° clockwise to 70° maximum distance 60 NM
70° clockwise to 200° maximum distance 30 NM
200° clockwise to 260° maximum distance 70 NM

Circular RADEX around GZ, 15 NM radius.
(Note: A recommendation was made to move the Control Destroyer to true bearing from GZ of 270° and 90 NM.)

Instructions were issued for the first two cloud trackers (Wilson 2 and Wilson 3). Wilson 2 was directed to perform a racetrack holding pattern 50 NM west of GZ at 10,000 feet from H plus 2 to H plus 5 hours followed by an upwind search at 10,000 feet in the sector 65° to 95° true bearings from GZ out to 500 NM. Wilson 3 was directed to perform a racetrack pattern beneath Wilson 2 from H plus 2 hours until released, flight altitude at the discretion of the pilot to remain clear of natural clouds but not in excess of 6,000 feet.

Since the task force fleet was located east-southeast of GZ at about 25 to 35 NM, and based on the latest forecast winds, it was recommended that the slow ships move further out to 50 NM on a bearing line of 120° true from their current position, and that the remaining larger ships head south after H-hour firing requirements were completed. This plan of ship movements was such that all local early fall-out passed between the fleet and GZ.

An advisory was passed at approximately H minus 6 hours to the British Sampling Unit at KWAJALEIN giving forecast cloud trajectories, forecast local winds for shot time, forecast area for British Unit operations, authority to penetrate the Danger Area, information to the effect that scramble and route instructions would be issued separately at approximately H plus 1½ hours, and a directive to file flight plans through the KWAJALEIN Liaison Officer using the advisory as authority for YANKEE flights.

It was recommended that the PC boat supporting the RONGERIK weather station detachment have all personnel aboard upon completion of the 050900M rawin run and be prepared to depart (in event of fall-out) on a southerly course.

The 0430M weather/radsafe check being favorable, and no transient ships contacted in Area GREEN, all efforts were devoted toward getting the shot off on time. As for the past shots, a final check was made of the latest BIKINI wind observations run from the USS CURTISS, the run being available approximately one-half hour before H-hour. The fact that the low level winds veered around counter-clockwise with ascending altitude (see hodographs) was the primary pre-shot concern; however, it was felt that the only adverse effects of these winds would be relatively high intensities on the southern islands and a possibility of significant contamination in the area between the task force fleet and GZ. Since YANKEE was the last BIKINI shot, the local contamination aspect was of no consequence. Against the possibility of contaminating the fleet, the proposed moves of the fleet to the south (as recommended above) were made and considered adequate. In addition, it was planned as on previous shots, to divert Wilson 3 to a survey of the questionable areas. These measures proved adequate.

Transient shipping contacts being favorable, YANKEE was detonated from a barge in the BIKINI Lagoon off YUROCHI in approximately the same location as UNION at 050610M, May 1954, and without undue incident to the embarked task force personnel and ships. Post-shot advisories were issued within H plus 30 minutes to the Chairman, AEC, C/S, USA and CINCPACFLT as on past shots, indicating time of detonation and a general statement of safety of personnel. The larger ships, relieved of operational requirements to remain close-in, turned south to an area 50 NM from GZ.

At approximately H plus 2 hours, a dense cloud was reported in such a position that fall-out would be likely to occur on the fleet. Wilson 3 had been diverted to a point 20 NM southeast of NAN to define the southern edge of any contamination in the area. Since no contamination was encountered on this portion of the Wilson 3 flight, the dense cloud was ascribed to a natural origin. Wilson 3, according to plan, next over-flew NAN and the airstrip obtaining 500 feet readings over NAN of 2 r/hr and 600 to 850 mr/hr over the airstrip. Wilson 3 also reported the airstrip considerably ridden with debris and wash-over. Subsequent ground and low-level surveys of these sites indicated that the Wilson 3 readings were mostly the result of air contamination, supporting a general theory that water surface shots (except very close-in) produce a predominately aerosol-type cloud with relatively little associated fall-out.

Based on Wilson 3 reports, a recommendation was made to turn the fleet around and steam to a point 10 NM south of NAN. Upon arriving at this position at about H plus 3 hours, slight contamination (1 to 3 mr/hr) was detected on some ships. Since no increase in intensities was detected over a period of time, the original recommendation to collect the fleet at this point was not changed.

Based on the observations of Wilson 3 and the 050600M wind observations, the PC boat at RONGERIK was directed to proceed to a point 50 NM south of RONGERIK upon completion of their 0900M rawin run. This was a precautionary measure taken on the assumption that long-range fall-out from water surface shots might have undesirable characteristics not yet observed on previous shots of this type, and because further wind runs were not essential for RONGERIK. Subsequent surveys on Y and Y plus 1 day indicated little or no fall-out occurred at RONGERIK.

Based on the preliminary helicopter damage and radsafe survey made between about H plus 3 and H plus 4 hours, an alert advisory was issued to all task force units. This advisory indicated that contamination on NAN, at NAN Anchorages and on the airstrip, was not prohibitive, but that the airstrip was so debris-ridden as to preclude flight operations at least on shot day. R-hour was estimated to be at 1330M and CTG 7.3 was directed to have all ships off the lagoon entrance by 1300M pending outcome of the lagoon water sampling of the NAN and HOW island anchorages.

The lagoon water sampling effort, having indicated relatively high intensities at the HOW and NAN anchorages, became the basis for recommending a delay in re-entering the lagoon to allow further decay and diffusion. An appropriate directive was issued designating R-hour as 1600M and declaring water and air traffic to NAN anchorages and the airstrip Radsafe unrestricted provided no landings were made on islands west of SUGAR. All other traffic was declared radsafe restricted and under the Radsafe Control of the Radsafe CENTER of TG 7.1. Swimming in the lagoon was prohibited until further notice and all units were alerted to the possibility of light secondary fall-out on the afternoon or evening of Y day. (No secondary fall-out materialized. None of the task force ships experienced significant fall-out from YANKEE.)

On the basis of the relatively significant contamination at the anchorages, it was ultimately decided to re-enter only with the major ships, i.e., the ships serving as the major "hotel" facilities for task force personnel. This was in conjunction with the BIKINI roll-up plan and to re-shuffle personnel, some to remain at BIKINI, others to return to ENIWETOK. Following the re-grouping, all ships left the lagoon to remain at sea over-night or to depart for ENIWETOK according to the roll-up plans. Subsequent to shot day, lagoon contamination problems were limited primarily to high contamination down current from GZ.

By noon of shot day, it was evident (from the racetrack cloud trackers) that ENIWETOK would not be contaminated. This was confirmed at 1900M (shot day) by a report from the Radsafe alert system at ENIWETOK, indicating FRED, ELMER and URSULA with negative contamination. NYKOPO Flight ABLE was scheduled for Y plus 1 day and directed to make preliminary in-flight reports at RONGERIK and TAKA.

Cloud tracking operations subsequent to noon on shot day were mostly routine and in accordance with plan except that no flights were performed after H plus 24 hours. (See inclosure reference YANKEE Air Radsafe Operations.) Some unusual features were as follows: Wilson 4 (a replacement for Wilson 3, which picked up a 1 r/hr aircraft background in the vicinity of BIKINI Island) conducted a low level survey of the northern Marshalls between 1400M and 1740M on shot day at altitudes of 100 to 400 feet. This survey included WOTHO, AILINGINAE, RONGELAP, RONGERIK, UTIRIK, AILUK and LIKIEP. No significant contamination was detected. (It should be noted that the instruments available to the cloud trackers, although of the same kind, were not nearly as sensitive as those used by the surveys made by the New York Operations Office. The negative results obtained were sufficiently accurate to state only that significant contamination (more than about 10 mr/hr) was not present. A further limitation lies in the fact that serious contamination could possibly occur later than the afternoon of shot day. For this reason, the precision survey flights for the New York Operations Office were scheduled for shot day plus one at the earliest.)

In an attempt to obtain maximum documentation of YANKEE, Wilson 5 was directed to search a sector from true bearings 40° to 70° out to maximum range at 10,000 feet from H plus 14 to H plus 21 hours. The information from this flight was extremely useful in analyzing the long-range fall-out pattern. Based on a cloud tracker contact with the cloud 50-70 NM north of BIKAR at 052030M (1.0 to 6.0 r/hr at 10,000 feet) all units were again alerted to the possibility of light fall-out in the BIKINI area by approximately day-break on 6 May. This fall-out did not materialize, nor did NYKOPO Flight ABLE record corresponding intensities at BIKAR on Y plus 1 day, thus furnishing further evidence of the aerosol, fall-out-resistant characteristics of the clouds from water surface shots. (See Air Radsafe Operations inclosure for further details on the cloud tracking efforts.)

In accordance with plan, CINCPACFLT was advised at 2000M on shot day of the current radsafe situation. This advisory consisted of the following: No significant change in the forecast 72-hour air particle trajectories, no known fall-out existing or forecast for surface and air routes except as previously indicated relative to closing the KWAJALEIN-GUAM air route. The advisory further stated that cloud tracking results on Y day indicated the main portion of the cloud passed to the east-northeast and well to the north of a line through RONGELAP and UTIRIK, and that low level flights over the northern Marshalls on shot day indicated contamination less than 10 mr/hr from YANKEE. CINCPACFLT was also advised that NYKOPO Flight ABLE was scheduled for Y plus 1 day.

On 6 May information was received relative to a contact with contamination made by two LST's enroute in company from ENIWETOK to Pearl. The incident involved an area approximately 700 NM east-northeast of GZ from approximately H plus 35 to H plus 41 hours. One of the ships, LST 762, was equipped with standard task force wash-down equipment. The other, LST

975, had only standard fire-fighting equipment. The first report gave their position as 12-56N, 176-51E at 061300M with radiation intensities of 15 mr/hr and increasing and that the LST's were carrying out decontamination procedures. A subsequent report stated their 061700M readings were 20 mr/hr average and 40 mr/hr high, with the highest readings on wind exposed surfaces. The report gave their 062000M position as 13-16N, 177-97E. A further report indicated a steady decrease after 062330M and that decontamination had been carried out during the night. LST 762 reached a high of 40 mr/hr; LST 975, 96 mr/hr. By 070800M (position 14-30N, 178-40E) intensities had dropped to an average of 5 mr/hr and a high of 15 mr/hr. A final report, position 15-05N, 178-44E, was received for 080700M indicating LST 762 with an average of 3 mr/hr and a high of 8 mr/hr, and LST 975 with 7 and 10 mr/hr respectively. Throughout this incident, and considering the intensities reported, the atomic countermeasures being taken and the prescribed route for the LST's, no special action was taken by the task force. The facts are reported primarily for their bearing on the aerosol characteristics of the water surface shot cloud.

On Y plus 1 day the second and final 2000M advisory was dispatched to CINCPACFLT. This advisory included a preliminary report on NYKOPO Flight ABLE (Y plus 1 day) which indicated all populated atolls from LAE through TAKA less than 10 mr/hr from YANKEE. The maximum reading was given as 13 mr/hr at BIKAR at 071315M and an estimate that BIKAR was on the approximate center line of the major fall-out pattern. The next highest reading was 1 mr/hr at KWAJALEIN, UTIRIK and TAKA. Subsequent atolls on Flight ABLE indicated essentially negative results. CINCPACFLT was advised that the Radsafe roll-up plan for the final shot (NECTAR) would include NYKOPO Flight ABLE on N plus 1 day, Flights ABLE, BAKER and CHARLIE on N plus 2 days, and that CINCPACFLT would be advised of the results prior to departure of cognizant personnel from the forward area.

On 6 May, the TG 7.3 unit on KWAJALEIN (charged by the task force with radsafe monitor responsibilities for KWAJALEIN) reported 1 mr/hr maximum background of that atoll at 061645M.

On YANKEE shot an attempt was made by the New York Operations Office, AEC to place styrofoam rafts in the forecast fall-out area. Rafts were placed by air-drop in the quadrant 10° to 100°. The project failed due to the few rafts recovered, and due to high water background obscuring aerial "fly-over" readings. This difficulty, however, pointed the way to a much simpler method of determining the pattern, i.e., by aerial survey of the ocean water itself. Some work along this line was accomplished on YANKEE, however, restrictions on available aircraft, and the absence of advance plans for this type measurement, limited the scope of the activities. An appreciation of the intensities observed is indicated in the following aircraft survey results:

Morning of 8 May: 2 mr/hr at 300 feet and 3 mr/hr at 150 feet measured on flight track 325° through 12-03N, 165-35E, band 4 miles wide around this point.

Afternoon of 8 May: 4 mr/hr at 200 feet at 12-16N, 165-59E.

Also, on this shot, Project 2.5a (Fall-out Distribution) attempted a technique to describe the fall-out pattern using surface craft to sample the water for activity and determination of mixing parameters and using vertical activity profiles with submerged radiac instruments. Although these efforts were limited in application to YANKEE (complete reports being submitted by the two agencies involved), their major contribution was a demonstration of the feasibility of these techniques and an impetus to more detailed and careful planning for the last shot.

On 10 May, information received from CTG 7.3 relative to ship contamination was passed to CINCPACFLT in accordance with a post-BRAVO request by CINCPACFLT for such information. The advisory indicated that insignificant contamination existed on manned ships, that LCU's left in the lagoon at H-hour read as high as 2 r/hr average upon re-entry. The 7 May readings were given as follows: 6 LCU's - 275 mr/hr; 3 LCU's - 500 mr/hr. The advisory further indicated that the lagoon was highly contaminated down current from GZ; no hazard was anticipated in the anchorage area, but some delay was expected in the recovery mission.

(Note: Activities of the AEC New York Operations Office had a considerable impact on task force post-shot off-site radsafe operations. Data from this source are being assembled by the Health and Safety Laboratory NYKOPO for presentation inthe form of a detailed report. Only pertinent excerpts from preliminary data were quoted above as they pertained to major portions of the task force Radsafe plan; however, continuous daily close coordination with the New York Operations Office group resulted in much mutual interest assistance for all. Further, similar close contact was maintained with the project personnel of Project 2.5a. The results of the Project 2.5a effort will eventually be presented in the form of a WB report. Since both these efforts included detailed studies of the off-site fall-out problems, it is suggested that any further study of this shot not over-look their final reports.)

8 Incls:

1. An Evaluation of Weather Forecasts for YANKEE
2. Tabulation of YANKEE pre-shot and post-shot winds from Task Force Stations.
3. Forecast and Computed YANKEE air particle trajectories
4. YANKEE Ground Zero Hodographs
5. YANKEE Shot-day Ground Radiation Intensities On-site
6. Air Radsafe Operations for YANKEE
7. Preliminary Results NYKOPO Airborne Monitoring Survey Flights o/a 5 May 1954
8. Summary of the Status of Transient Shipping in the PPA Area o/a 5 May 1954

AN EVALUATION OF WEATHER FORECASTS FOR YANKEE

1. Summary of weather immediately prior to Y-Day: Two days prior to the shot the synoptic pattern showed easterly flow to 10,000 feet. From 20,000 to 40,000 feet, a trough oriented east-west persisted approximately 4° north of the ENIWETOK-BIKINI area. A clockwise cell east of MAJURO dominated flow in levels 25,000 to 45,000 feet giving southerly components in these levels. On shot day minus one it was felt that the synoptic situation indicated that westerly flow would prevail through the northern Marshalls.

2. The Weather Forecast: 3/8 cumulus, base 2,000 feet, tops 7,000 feet, occasional tops 12,000 feet; 2/8 stratocumulus, base 3,500 feet, tops 4,500 feet; 3/8 altocumulus, base 22,000 feet, tops 24,000 feet; 5/8 cirrus, base 39,000 feet, tops 41,000 feet; scattered showers.

a. Observed weather: 2/8 cumulus, base 1,800 feet; 2/8 altostratus base 13,000 feet; 4/8 cirrostratus, base 35,000 feet. Very light rain showers were reported five hours prior to and two hours after shot time.

b. Comments on weather: Prior to shot time Wilson flights (reconnaissance aircraft near shot site) reported 5/8 cumulus, tops 6,000 to 8,000 feet, occasional tops at 10,000 feet; 2/8 to 5/8 altocumulus and altostratus, base 12,000 feet. One hour prior to shot time an altostratus base was reported at 21,000 feet. No rain showers were reported in the target area prior to shot time. Following the detonation, 5/8 to 7/8 cirrostratus was reported, bases ranging between 55,000 and 75,000 feet.

3. The Wind Forecast:

HEIGHT (Thsds Ft)	H-26	H-17	H-8	H-4	OBSERVED WINDS (H-hour)
90	090/60	090/65	090/55	090/55	
80	090/50	090/50	090/45	090/45	
70	090/30	090/35	090/20	090/20	
65	080/20	090/20	110/12	110/12	
60	070/10	090/08	180/06	180/06	
55	300/10	090/05	200/15	200/15	
50	280/25	280/30	200/40	200/40	250/44
45	260/40	270/35	260/50	260/50	280/56
40	260/35	260/40	260/55	240/55	Missing
35	250/30	250/37	240/40	220/40	Missing
30	240/25	250/31	220/30	220/30	220/34
25	230/20	260/20	240/45	230/25	230/23
20	150/10	250/12	300/15	260/15	290/14
18	150/10	230/10	270/10	300/15	280/19
16	120/10	210/07	320/08	310/10	320/13
14	100/10	Lt&Var	340/06	360/01	340/05
12	090/12	070/05	360/02	040/08	010/02

HEIGHT (Thsds Ft)	H-26	H-17	H-8	H-4	OBSERVED WINDS (H-hour)
10	080/15	070/11	020/08	060/15	020/05
08	080/15	070/18	040/12	080/25	070/11
06	080/22	070/18	060/22	080/28	070/20
04	080/25	070/26	070/28	070/25	080/23
02	070/20	070/27	060/25	060/25	080/25
SFC	070/18	060/20	070/23	060/20	080/24

a. Comments on winds:

(1) 73% of the forecast wind directions were within 20° of the observed. 87% of the forecast wind directions were within 30° of the observed. The greatest deviation from the forecast winds was 50° at 50,000 feet.

(2) 80% of the forecast wind speeds deviated 6 knots or less from the observed, and 93% deviated 10 knots or less. The maximum error 14 knots at 8,000 feet.

YANKEE

Date 5 MAY 1954 Time 0610 L Local Observation Time 041810 Z L

Clouds lower 5/10 CUMULUS Base 2000 FT. Tops 4500 FT. Middle 1/10 AC Base 20,000

FEW CU WITH TOPS TO 8000 FT. Visibility 8 Miles

Sea Level Pressure 1010.8 Mb Wind direction 070 degrees Velocity 20 Kts

Surface temp 80.8 °F Dew Point 75.0 °F Humidity 84 % Vapor pressure 1.056

Local weather PARTLY CLOUDY Remarks RAIN SHOWERS IN AREA. NO INDUCED RAIN SHOWERS OBSERVED.

Latest winds aloft taken on CURTISS Position 11.2 165.9 Time 0600L

ALTITUDE	DEGREES	KNOTS	PRESSURE	TEMP	DEW POINT	RELATIVE HUMIDITY
Surface	080	24	1010.8	27.1 °C	23.9 °C	83 %
1,000 Ft	070	23	980	24.5	22.7	90
1,500	075	24	959	22.2	20.2	88
2,000	080	25	945	21.9	20.0	91
3,000	080	24	910	20.1	18.7	92
4,000	080	23	879	18.6	17.4	92
5,000	070	20	850	17.0	16.0	93
6,000	070	20	820	15.7	13.8	90
7,000	070	18	790	14.2	11.0	81
8,000	070	11	763	12.7	6.2	70
9,000	040	06	737	10.8	1.0	51
10,000	020	05	710	9.4	3.0	65
12,000	010	05	663	6.0	-0.8	63
14,000	340	05	616	3.3	-17.3	20
16,000	320	13	572	0.4	MB	MB
18,000	280	09	528	-3.0	-18.0	30
20,000	290	14	491	-6.6	-17.8	43
25,000	230	23	398	-19.6	-24.0	61
30,000	220	34	322	-29.0	MB	MB
35,000	MISG		259	-39.0	MB	MB
40,000	MISG		207	-46.0	MB	MB
45,000	280	56				
50,000	250	44				
52,000	200	46				
60,000						
65,000						
70,000						
75,000						
80,000						
85,000						
90,000						
95,000						
100,000						
105,000						
110,000				0-10		

BIKINI-YANKEE SHOT, 0610M, 5 MAY 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0621	0623	0824	0516	0213
2000	0821	0723	0825	0725	0819
4000	0926	0925	0823	0722	0920
6000	0924	0926	0720	0920	0916
8000	0610	0714	0711	0411	1110
10000	0307	0409	0205	3202	1409
12000	3506	0203	0105	2902	1806
14000	3212	3514	3405	3508	2104
16000	3110	3206	3213	2406	2305
18000	2915	2808	2809	3311	2410
20000	2612	2708	2914	2609	2609
25000	Missing	2529	2323	2535	2528
30000	2240	2234	2234	2416	2637
35000	2536	2652	Missing	2614	2757
40000	2663	2665	Missing	2625	2650
45000	2759	2539	2856	2840	2812
50000	2635	2648	2544		1726
55000	2415	2113			1432
60000					1440

ENIWETOK-YANKEE SHOT, 0610M, 5 MAY 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+6 hours
Surface	0719	0619	0617	0417	0517
2000	0725	0724	0823	0723	0724
4000	0826	0821	0921	1025	0823
6000	0829	0826	0918	1020	0822
8000	0820	0816	0714	0812	0808
10000	0816	0512	0508	0504	0505
12000	0411	0312	0405	0307	2505
14000	0507	3304	0104	0306	0904
16000	Calm	0107	3303	0705	1803
18000	0209	3003	3308	3604	2506
20000	2907	3108	3211	3311	3112
25000	2416	2417	2423	2527	2728
30000	2325	2628	2728	2626	2734
35000	2854	2629	2744	2852	2742
40000	2761	2861	2665	2755	2758
45000	2760	2851	2753	2753	2763
50000	2835	2838	2741	2736	2746
55000	2706	2706	2804	2806	2712
60000	0805	0603	0806	0604	Calm
65000	0404	1019	0919	0924	0917
70000		1027	0935	1039	1030
75000		1046	1053	1045	1033
80000		1048	1160	1050	1043
85000		1151	0845	1044	1048
90000		1053	0848	0943	0946
95000		0957		1036	1045
100000				1130	1242
105000					1030
110000					0944

KUSAIE-YANKEE SHOT, 0610M, 5 MAY 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+8 hours
Surface	0704	0706	0908	0903	0705
2000	0813	0817	0913	0913	0916
4000	0823	0922	1020	1022	0818
6000	0829	0926	1029	0930	0929
8000	0831	0927	0928	0931	0935
10000	0824	0821	0928	0917	1020
12000	0817	0816	0916	0922	0916
14000	0819	0817	0917	0927	0820
16000	0815	0815	0816	0820	0820
18000	0813	0815	0820	0611	0813
20000	0704	0707	0614	0608	1108
25000	2304	2103	1509	2310	2113
30000	2610	2712	2514	2616	2413
35000	2824	2719	2723	2315	2216
40000	2616	2619	2419	2730	2633
45000	2825	2824	2838	2837	2940
50000	2827	2926	3039	2830	2731
55000	2535	2532	2633	2531	2830
60000	2728	2835	2935	2931	2719
65000	0314	0821	1042	1024	1014
70000	0946	1049	0949	0847	0940
75000	0967	0965	1043	0959	0853
80000	1062	1065	1041	1062	0954
85000	0958	0963		0857	1060
90000	0961	0961		1048	
95000	0958	0959		1057	
100000		0931			

KWAJALEIN-YANKEE SHOT, 0610M, 5 MAY 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0712	0712	0718	0512	0312
2000	0829	1025	0718	0719	0620
4000	0835	0924	0919	0917	0717
6000	0827	0825	0922	1120	0915
8000	0823	0616	0922	1121	1115
10000	0616	0725	0815	1019	1116
12000	0714	0715	0815	0817	1212
14000	0711	0813	0811	0910	1008
16000	0711	0608	0806	0806	1009
18000	0506	0105	0405	0405	0702
20000	0307	3003	3604	0804	2003
25000	2230	2025	2217	2216	2321
30000	2120	2326	2426	2426	2732
35000	2529	2732	2735	2833	2738
40000	2639	2748	2847	2745	2648
45000	2835	2732	2851	2844	2743
50000	2535	2732		2634	2626
55000	2622	2725		2833	2818
60000	2512			2806	2604
65000	0713			0923	1104
70000	0834			0929	0941
75000	0857			0845	1057
80000	0850			0855	0945
85000	0951			1054	0753
90000				0957	1241

MAJURO-YANKEE SHOT, 0610M, 5 MAY 1954

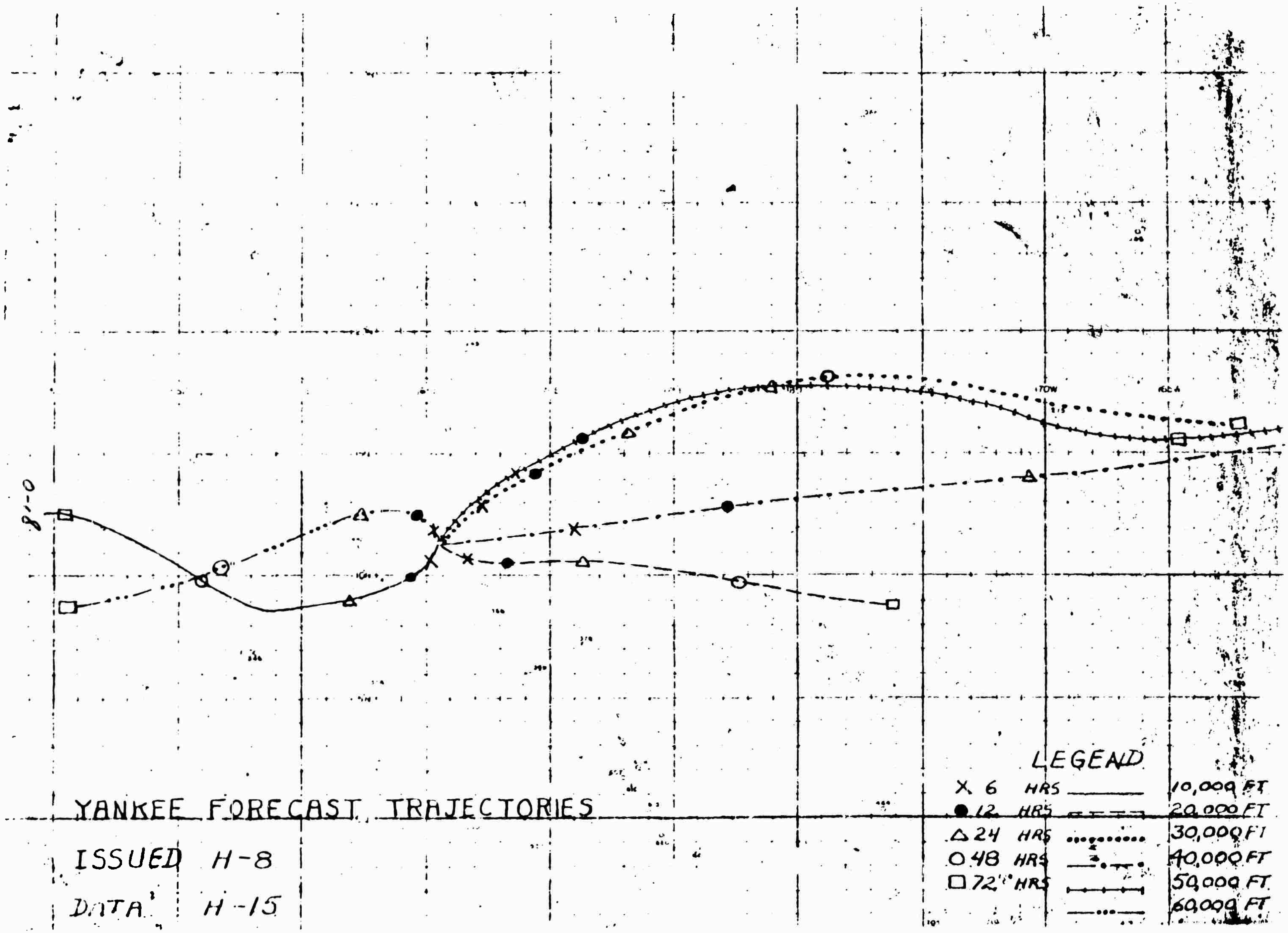
LEVEL	H-5 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	Calm	0507	0707	0604	0904
2000	0620	0517	Missing	0718	0917
4000	0735	0825	Missing	0724	0918
6000	0831	0926	Missing	0720	0914
8000	0831	0825	0822	0916	0816
10000	0728	0824	0819	0819	0714
12000	0623	0621	0718	0819	0714
14000	0620	0717	0619	0618	0612
16000	0724	0718	0719	0513	0511
18000	0716	0514	0614	0611	3608
20000	0412	0508	0511	0406	0206
25000	1915	2015	1514	1214	1511
30000	2124	2116	2115	2021	2321
35000	2122	2323	2326	2723	2629
40000	2222	2628	2835	2739	2639
45000	2623	2840	2522	2746	2647
50000	2638	2527		2534	2637
55000	2634	2726		2619	2829
60000		1816		2608	2621
65000		0813		0811	0822
70000		0840		0941	0934
75000		0654		0855	0755
80000		0959		0857	0861
85000		0956		0855	0753
90000		0855		0759	0754
95000		0857		0859	1038
100000				1062	0943
105000				1041	0931

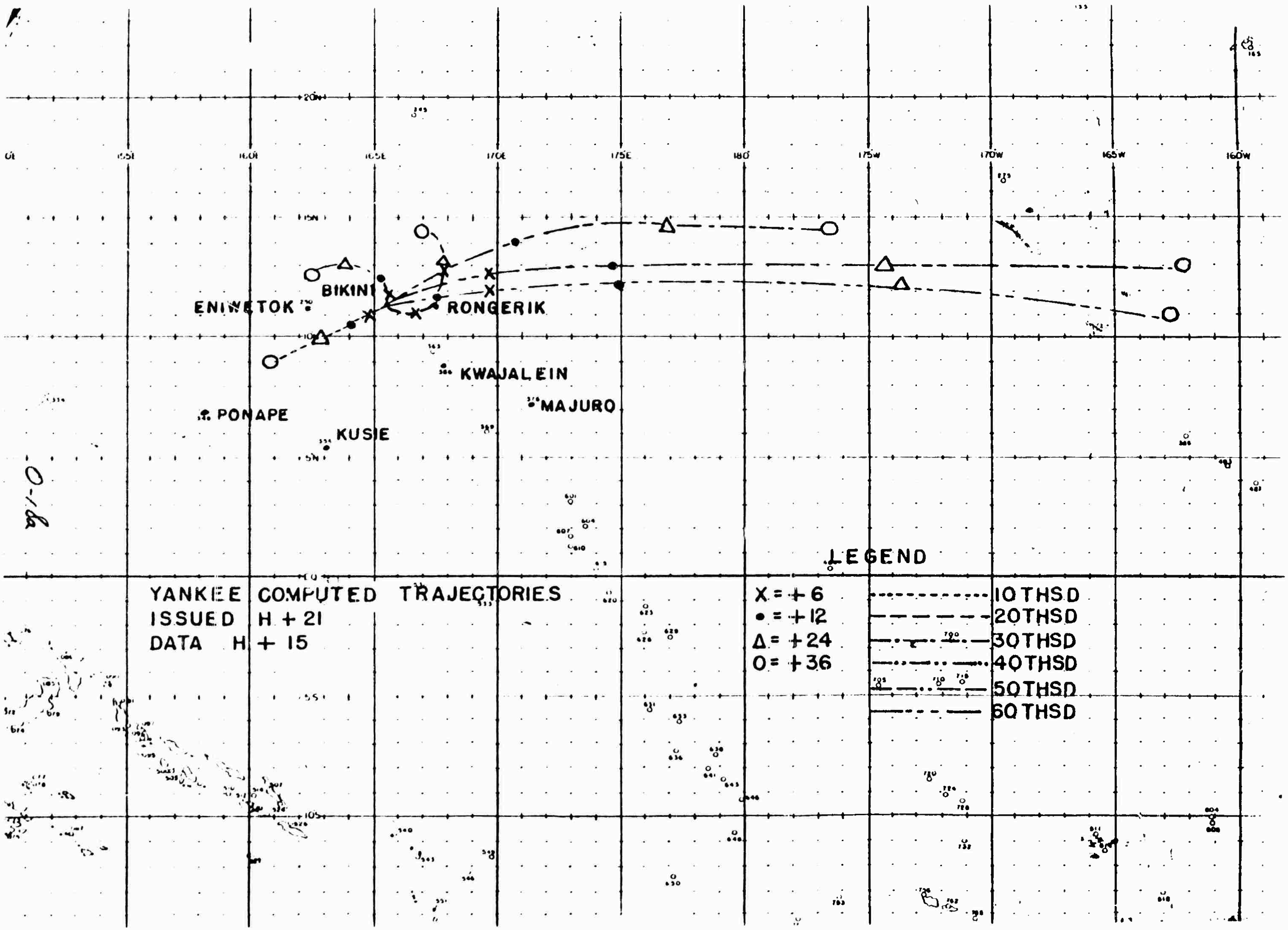
PONAPE YANKEE SHOT, 0610M, 5 MAY 1954

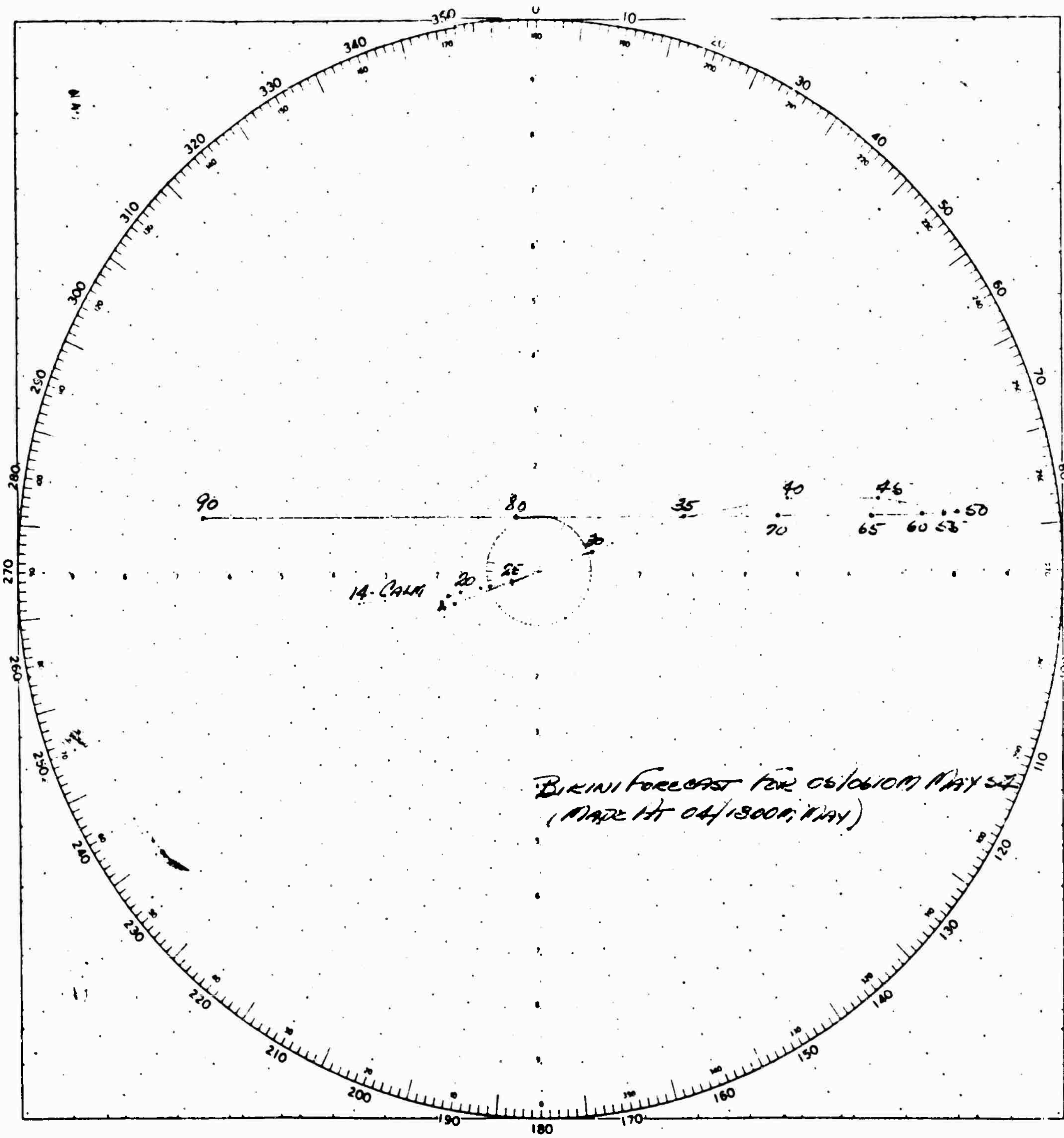
LEVEL	H-6 hours	H-3 hours	SHOT	H+4 hours	H+9 hours
Surface	0908	No Run Made	0906	0906	0905
2000	0830		0838	0831	0719
4000	0832		0937	0939	0830
6000	0935		0939	0940	0931
8000	0831		1033	0928	0922
10000	0824		0929	0820	0920
12000	0818		0928	0821	0920
14000	0815		0818	0506	0920
16000	0817		0813	0616	0922
18000	0710		0805	0824	0818
20000	2303		3302	2603	0813
25000	2503		2409	2505	2304
30000	2612		2617	2620	2716
35000	2718		2733	2631	2429
40000	2625		2637	2750	2837
45000	2741		2950	2844	2947
50000	2926		2928	2931	2834
55000	2418		2729	2725	2821
60000	2405		2610	2923	2718
65000	0117		0514	1115	0920
70000	0422			1045	1027
75000				0858	1042
80000				0965	0950
85000				0963	0952
90000				1057	0953
95000				1057	1049
100000				1052	1040

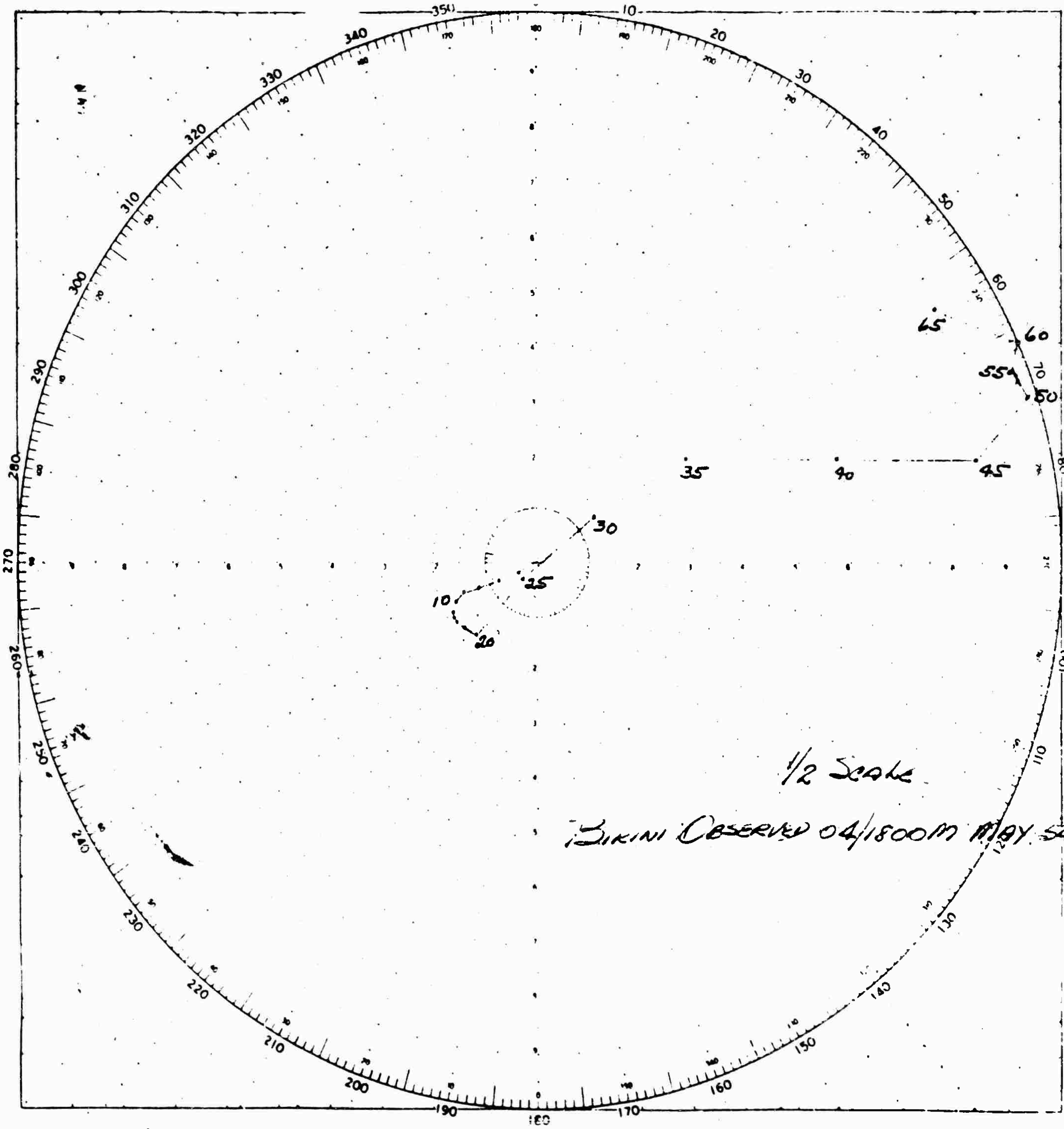
RONGERIK-YANKEE SHOT, 0610M, 5 MAY 1954

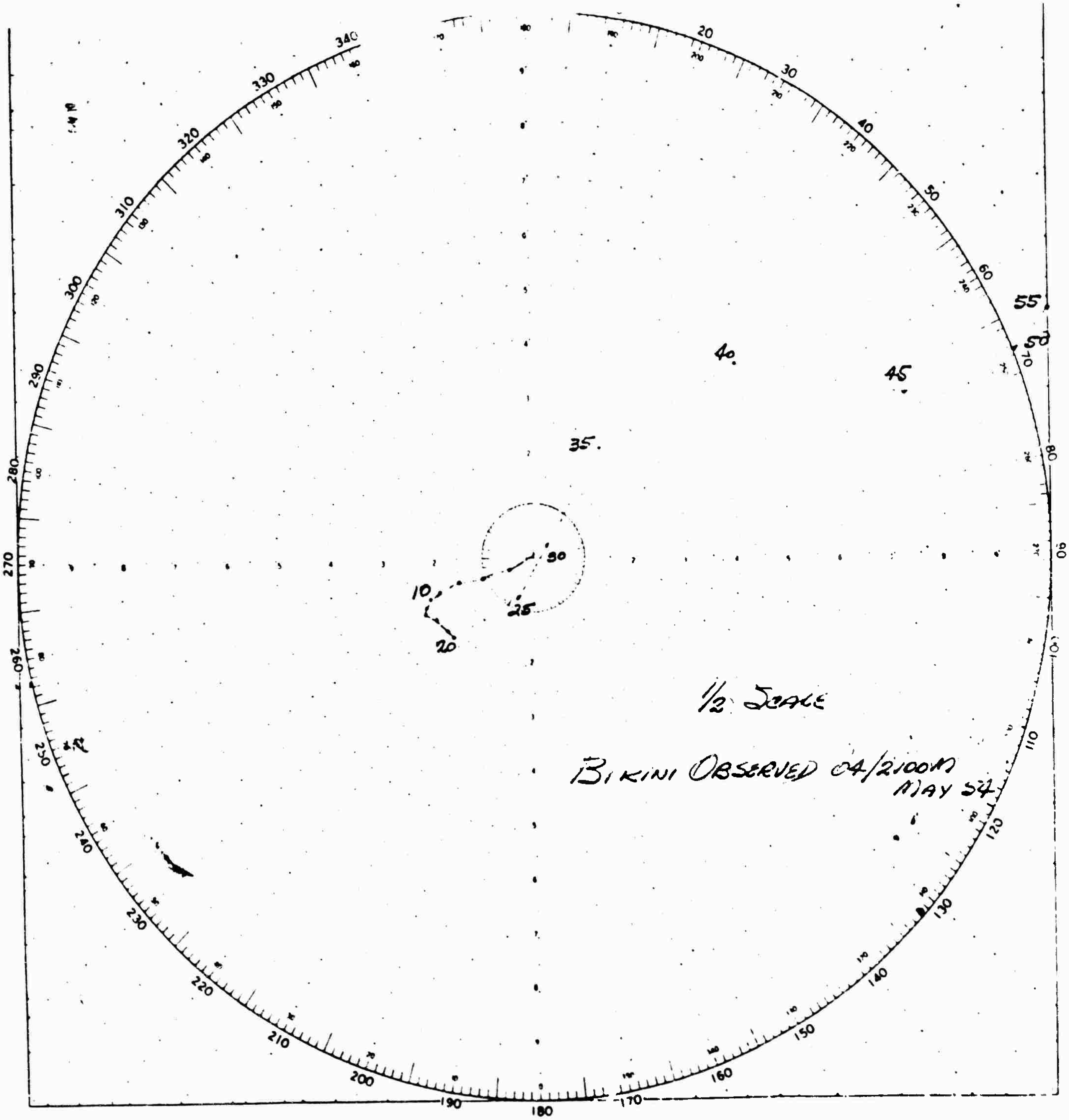
LEVEL	H-9 hours	H-5 hours	SHOT	H+3 hours	H+6 hours
Surface	0620	0823	0719	0715	No Run Made
2000	0629	0836	0824	0722	
4000	0934	0838	0819	0823	
6000	0833	0831	0915	0922	
8000	0717	0722	0916	1209	
10000	0311	0409	0707	0914	
12000	0307	1104	1310	1211	
14000	3505	3206	1405	1410	
16000	3106	2714	2304	2007	
18000	2507	2815	2807	2607	
20000	3114	3215	2512	2510	
25000	2320	2626	2527	Missing	
30000	2334	2344	2339	Missing	
35000	2440	2554	2650	Missing	
40000	2861	2770	2765	2741	
45000	2751	2766	2861	2843	
50000	2333	2545	2435	2536	
55000	2507	2514	2731	2814	
60000	1203	0911	2409	0109	
65000	0922		0216	1210	
70000	1019		0647	0755	
75000	0746		0841	1047	
80000	0856		1053	1047	
85000	0970		0951	0867	
90000	0952		0843	0941	
95000	0958			0940	

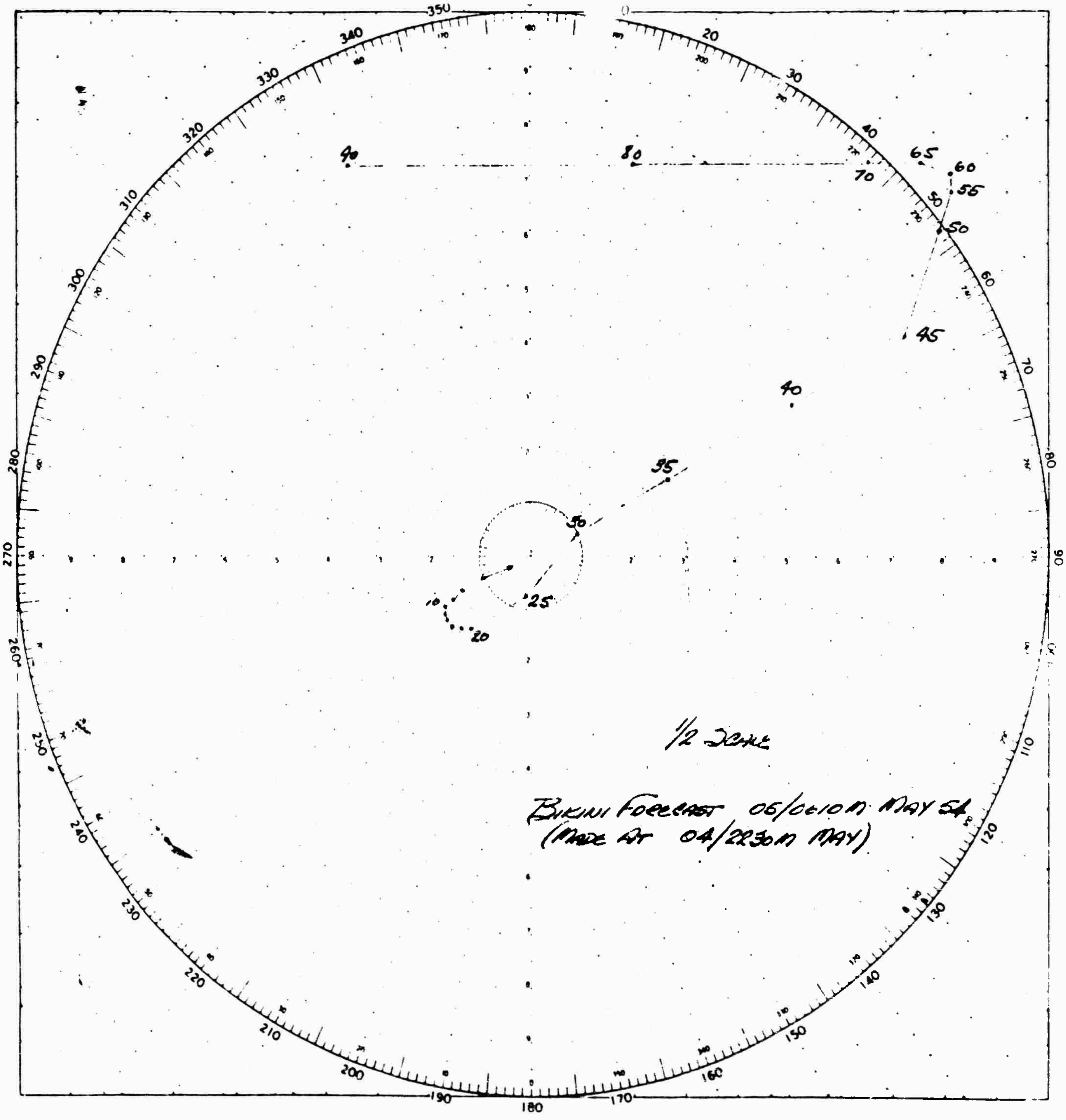

YANKEE FORECAST TRAJECTORIES
ISSUED H-8
DATA H-15
0-18
LEGEND
X 6 HRS 10,000 FT
● 12 HRS 20,000 FT
△ 24 HRS 30,000 FT
○ 48 HRS 40,000 FT
□ 72 HRS 50,000 FT
60,000 FT

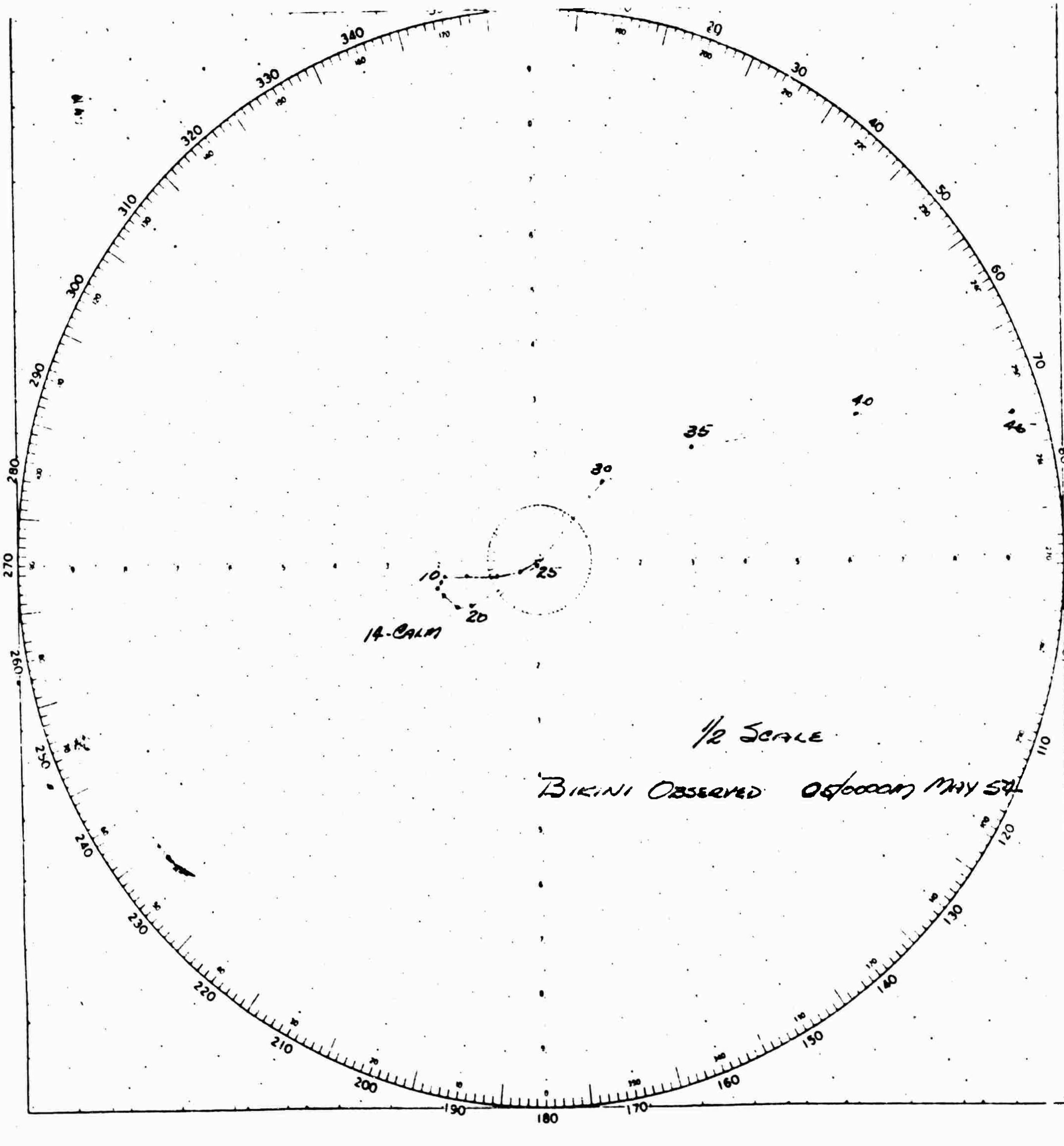

YANKEE COMPUTED TRAJECTORIES
ISSUED H + 21
DATA H + 15
LEGEND
X = + 6
• = + 12
Δ = + 24
O = + 36
10 THSD
20 THSD
30 THSD
40 THSD
50 THSD
60 THSD
ENIWETOK
BIKINI
RONGERIK
KWAJALEIN
MAJURO
PONAPE
KUSIE
20N
15N
10N
5N
150E
155E
160E
165E
170E
175E
180
175W
170W
165W
160W
0-16a

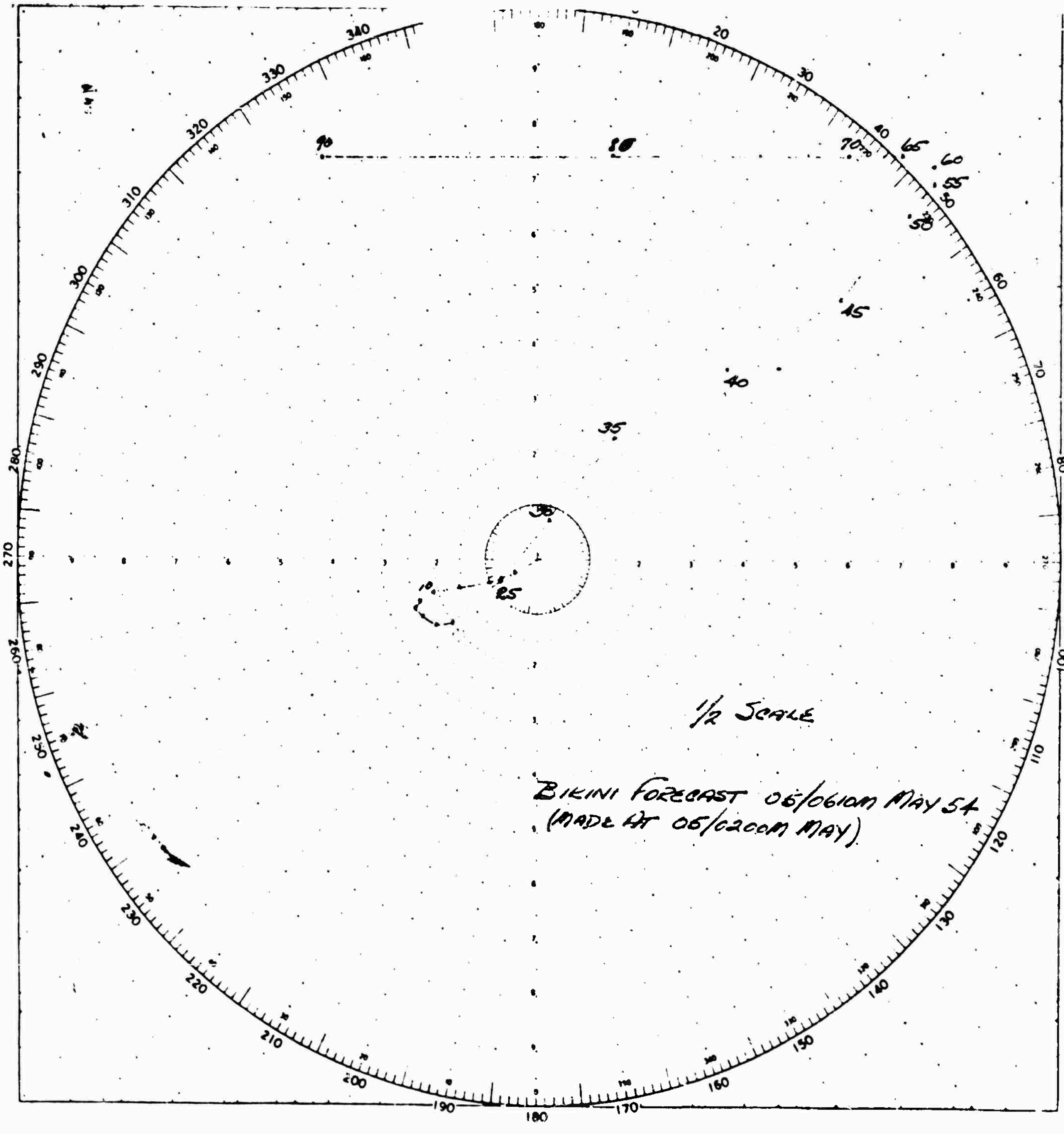

BIKINI FORECAST FOR 05/0610M MAY 52
(MADE AT 04/1300M MAY)
90
80
35
40
45
70
65
60
55
50
14 CALM
20
SE
30


1/2 Scale
Bikini Observed 04/1800M MAY 54
10
20
25
30
35
40
45
50
55
60
65

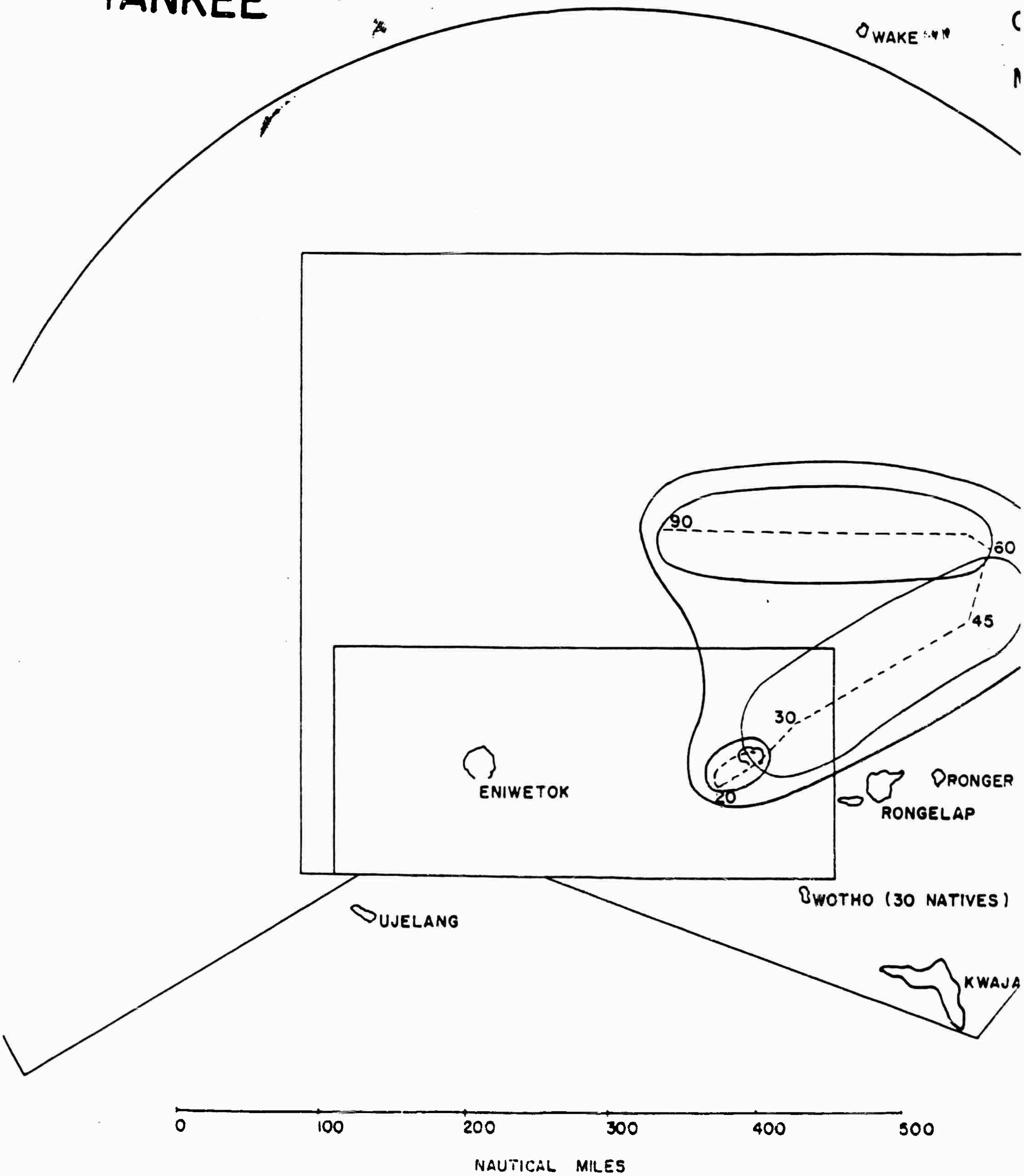

1/2 Scale
Bikini Observed 04/2100M May 54


1/2 SCALE
BIKINI FORECAST 06/0610M MAY 54
(MADE AT 04/2230M MAY)


1/2 Scale
Bikini Observed 06/0000m May 54
10
14-Calm
20
25
30
35
40
46


1/2 SCALE
BIKINI FORECAST 06/0610M MAY 54
(MADE AT 06/0200M MAY)

/ANKEE



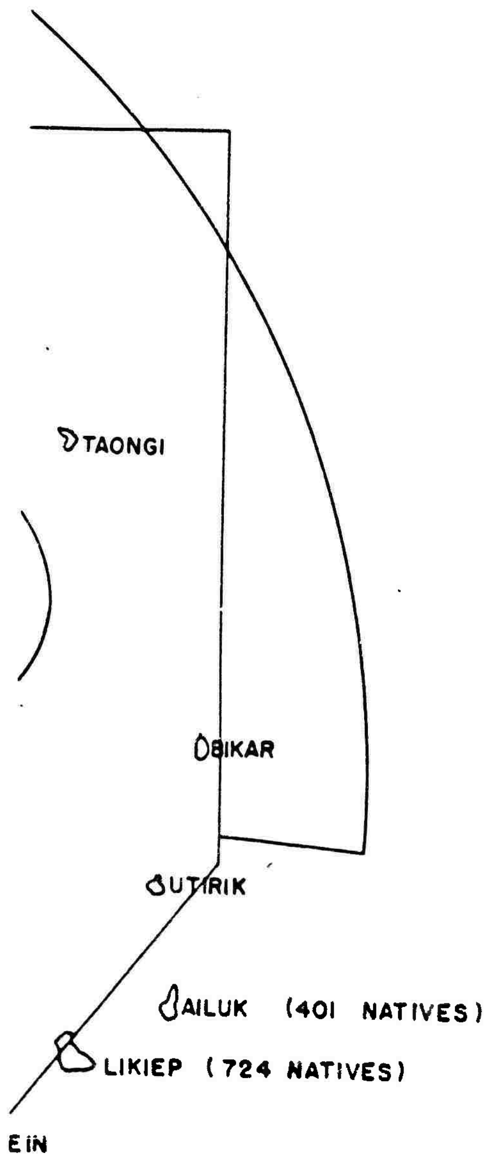
WAKE
90
60
45
30
20
ENIWETOK
RONGER
RONGELAP
WOTHO (30 NATIVES)
UJELANG
KWAJA
0
100
200
300
400
500
NAUTICAL MILES

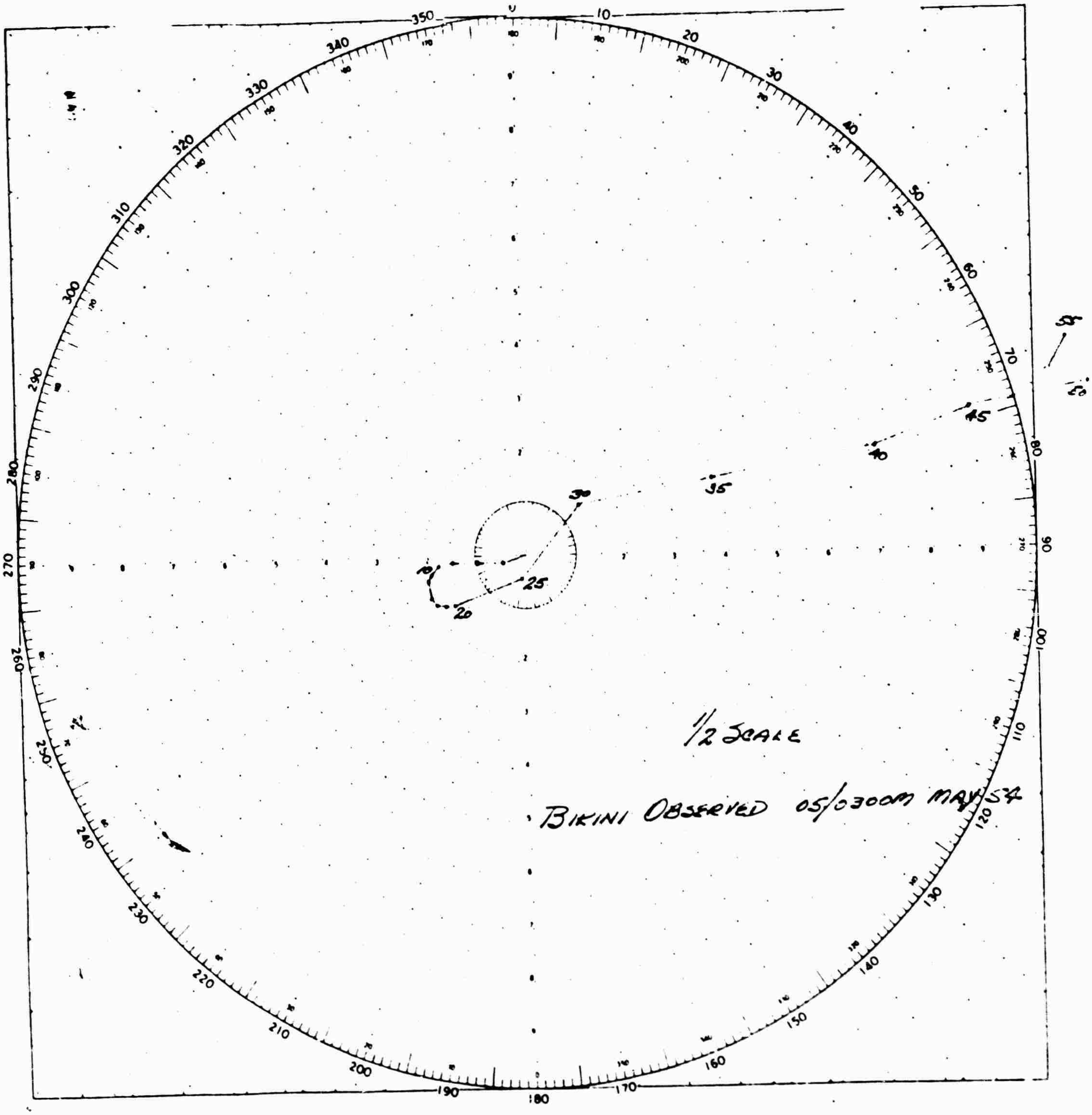
0-24a

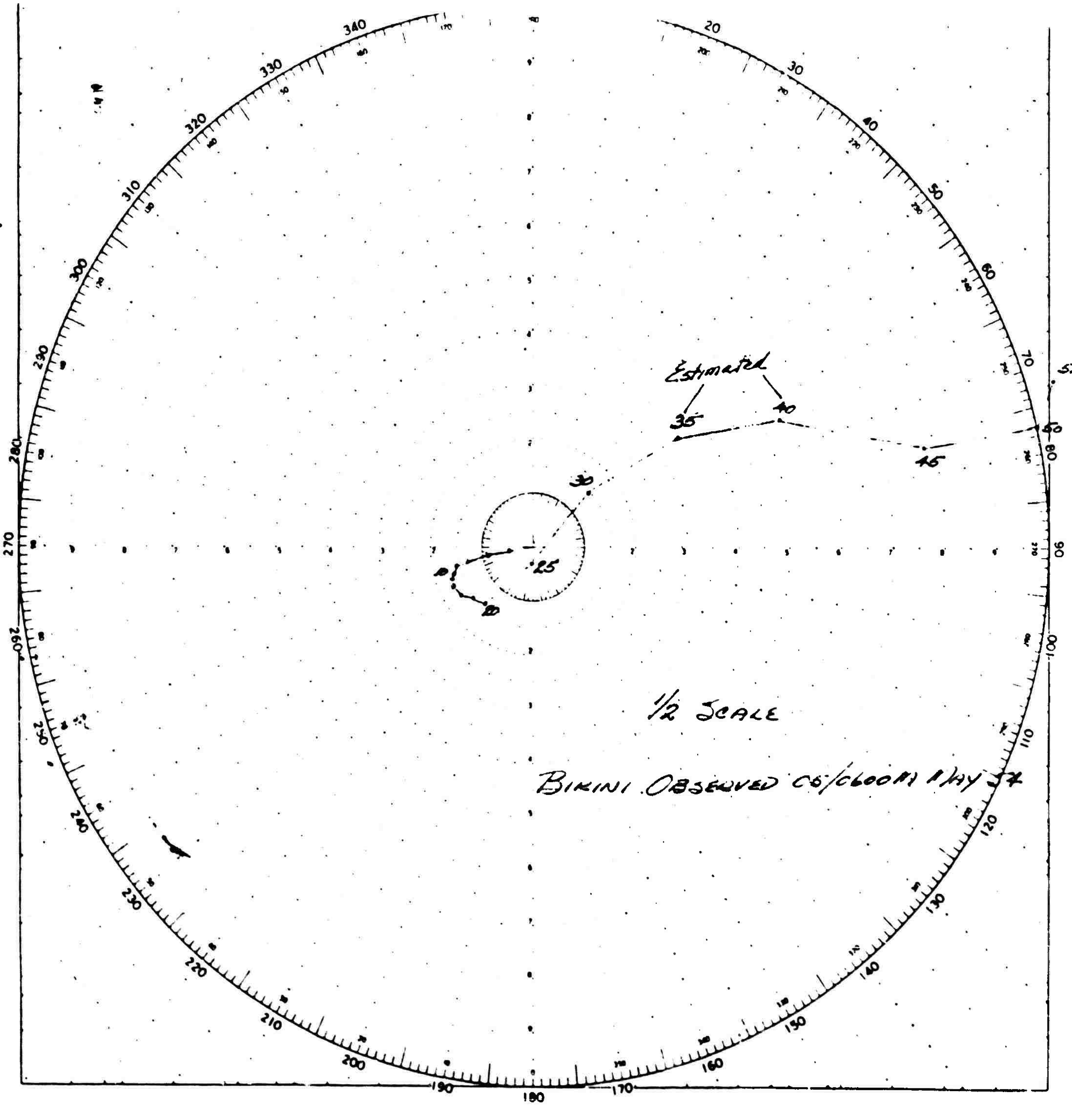
)RECAST FOR

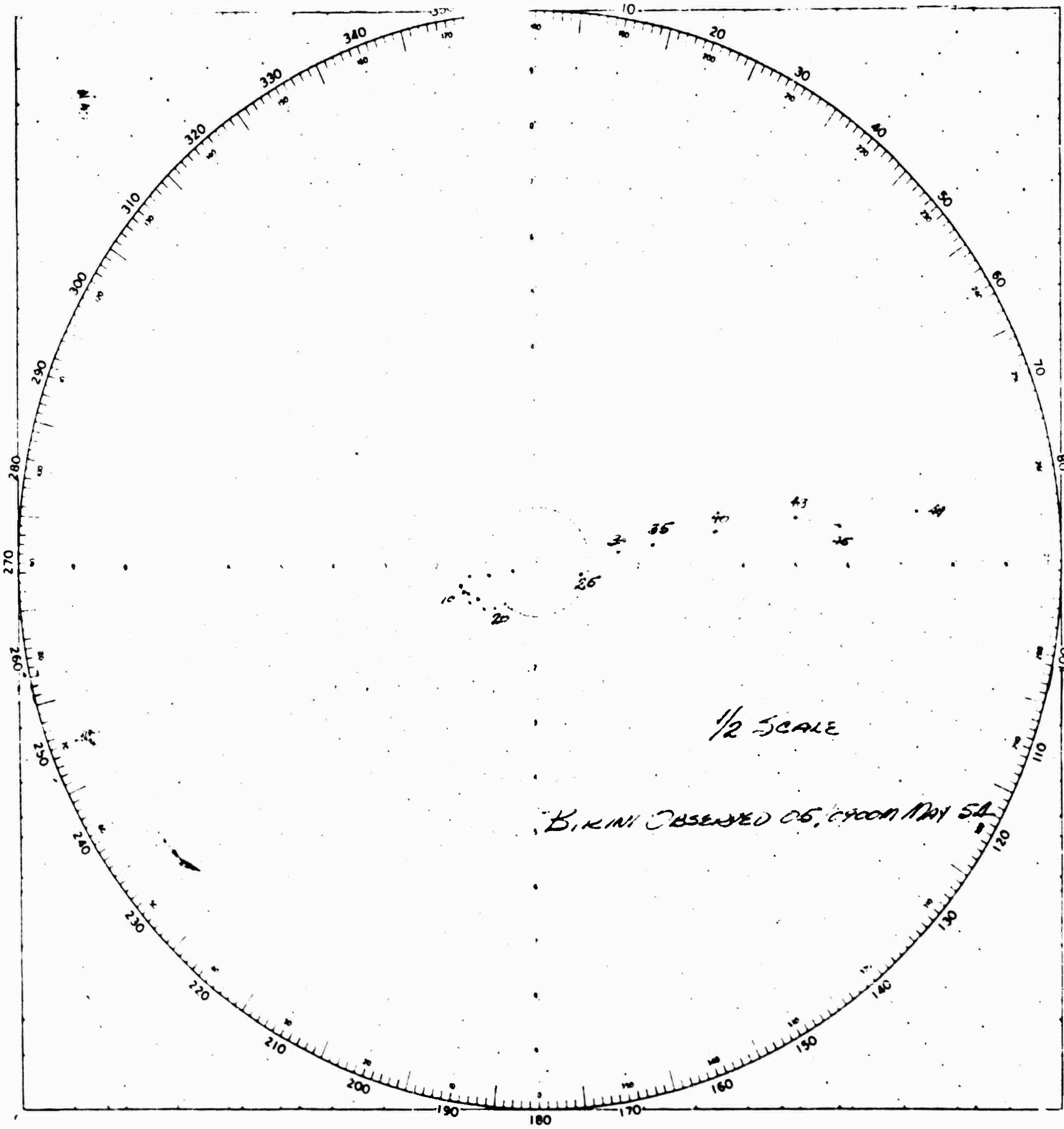
5/0610 M MAY 54

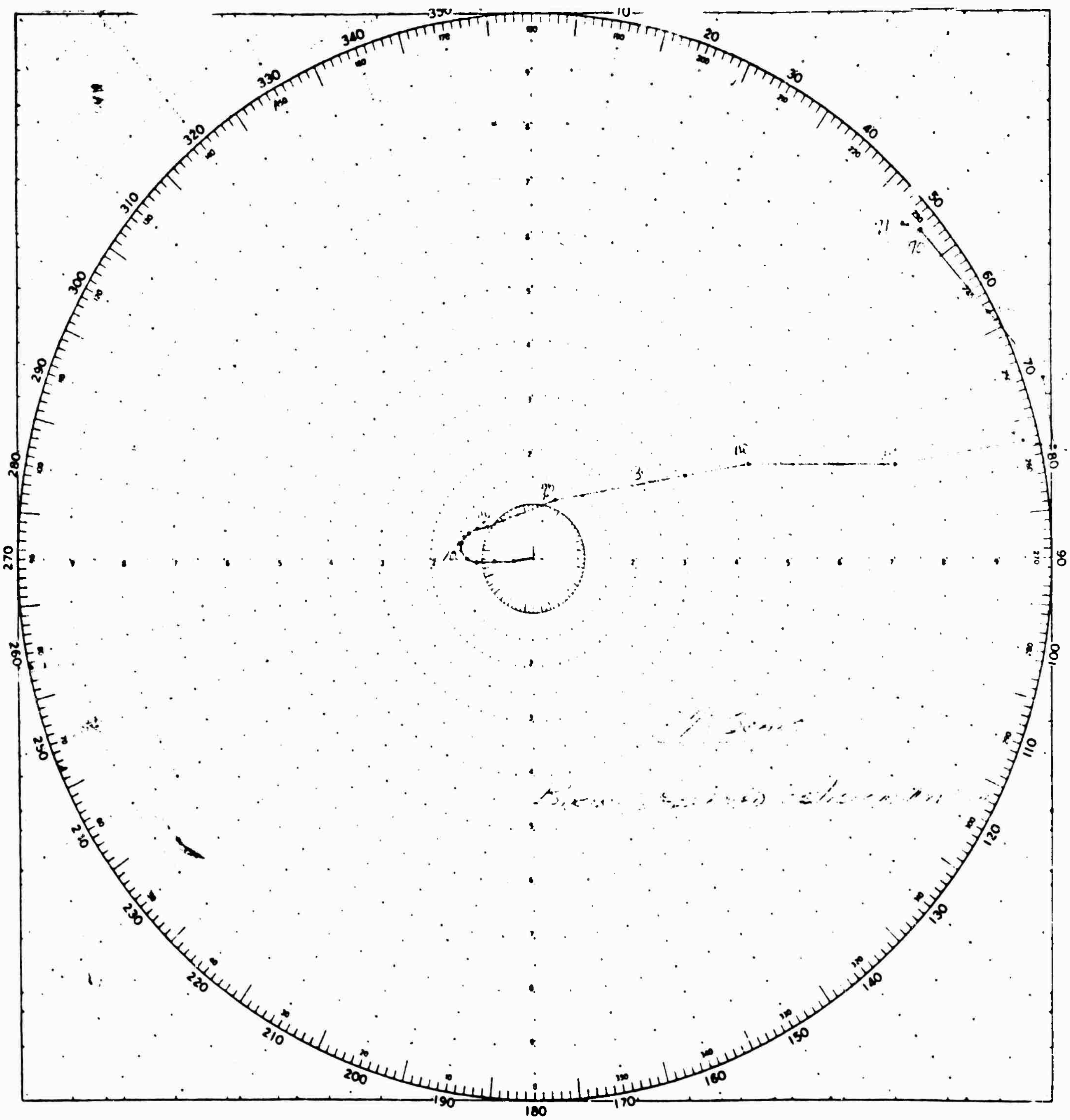
ADE 04/2230 M



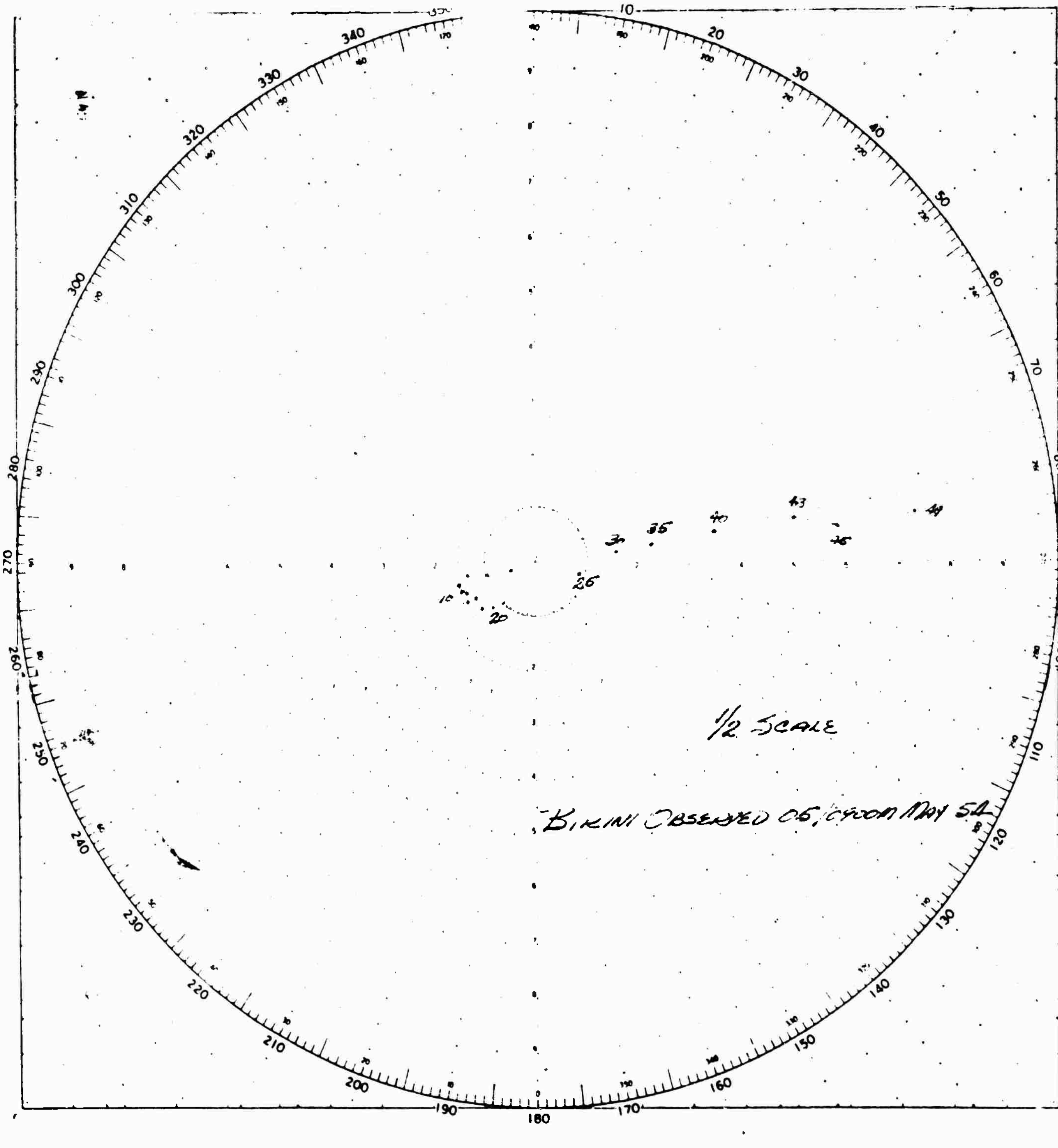

1/2 SCALE
BIKINI OBSERVED 05/0300M MAY 54
10
20
25
30
35
40
45
50


Estimated
35
40
45
50
52
30
25
10
20
1/2 SCALE
BIKINI OBSERVED C6/0600M 1 MAY 54


1/2 SCALE
BIKINI OBSERVED 06, 1400M MAY 54



0-28


1/2 SCALE
BIKINI OBSERVED 06, 0900M MAY 54
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
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280
290
300
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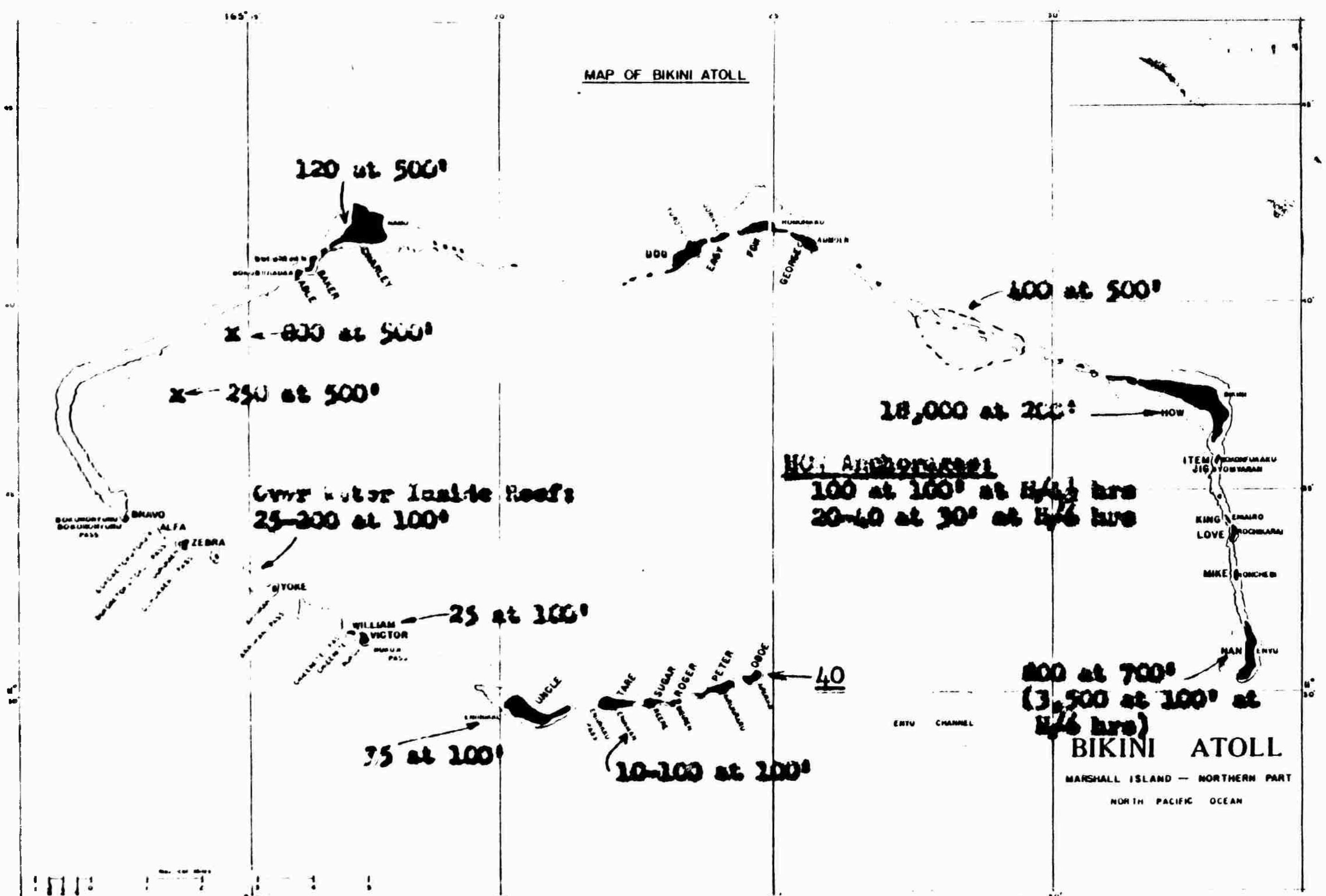
320
330
340
26
30
35
40
43
44
10
20



Radsafe Survey Readings YANKEE Day (approximately H+4 hrs)
(All readings in mr/hr; ground readings underlined)
Three samples taken at HQ anchorage (in 10^{-4} microcuries per milliliter
at approximately H+5 hrs: (1) 950 (2) 501 (3) 63

O-25

AIR RADSAFE OPERATIONS FOR YANKEE

1. SUMMARY:

The atomic device YANKEE of Operation CASTLE was detonated at 1810 hours Zebra, 4 May 1954 from a barge located at the north end of the BIKINI Lagoon. YANKEE cloud reached an altitude on the order of 115,000 feet. The Air Radsafe operations in connection with this detonation were successfully conducted and resulted in much timely information on the post-event conditions not only on the shot atoll of BIKINI but also the adjacent areas. Cloud tracking aircraft obtained data which indicated that the lowest section of the YANKEE cloud stem, up to perhaps fifteen thousand feet, was moving to the west-northwest at approximately 15 knots. This movement, plus the moderate intensities encountered (a maximum of 63 mr/hr), established the fact that this portion of the cloud did not constitute a hazard to ENIWETOK Atoll, 186 miles to the west of BIKINI. Other aircraft made contact with fall-out from the middle level (twenty to sixty thousand feet) of the cloud. As had been forecast by the pre-shot studies, this level was proved to be moving to the east-northeast at 15 knots. From the meteorological data one would predict that the mushroom moved to the north and to the west. Fall-out from this level, however, was carried to the east where several interceptions were made. On the basis of the foregoing it was apparent that there was no hazard to the populated atolls within or without the Pacific Proving Ground. This premise was verified when one of the cloud tracker aircraft was diverted for the purpose of making a minimum altitude radiological survey of all land masses which conceivably could have been affected by fall-out of YANKEE debris. This hurried survey showed essentially no areas to have received fall-out; a fact which was confirmed when a more leisurely and refined survey was possible. There was no evidence of significant fall-out outside the Pacific Proving Ground.

GENERAL:

a. Source of Information:

Cloud tracking information for YANKEE was available from five sources. The contribution of each of these sources, which are listed below, will be discussed in subsequent paragraphs:

Sampling Aircraft Reports
Sweet-Sour Reports
Special Cloud Tracking Flights
Weather Reconnaissance Flights
AFOAT-1 Flights

b. Overall Cloud Movement (within the PPG):

The observed BIKINI winds on YANKEE Day are plotted in the hodographs. The hodographs clearly show the relatively important effects that stem from minor changes in the meteorological conditions. In this case small changes in wind direction and velocity during the first three hours after YANKEE materially increased the possibility of fall-out on the atolls to the east of GZ (BIKINI Atoll). Fortunately the subsequent changes were of a more favorable nature and, if one considers the safety point of view alone, the net result was a most satisfactory situation. From the hodographs it can be seen that the YANKEE cloud, whose maximum height was of the order of 117,000 feet at 8 minutes, was subjected to 3 wind shears. The lowest level of the cloud (surface to 15,000 feet) was influenced by the winds from the east which averaged 15 knots. This movement was confirmed by a cloud tracking aircraft crew who reported a maximum intensity of 63 mr/hr 4 hours after shot time at a point 55 miles west-southwest of GZ at 10,000 feet. Based on the position of this contact and the forecast air trajectories, it is believed that this contamination passed to the south of ENIWETOK Atoll. Remnants of this portion of the cloud probably account for the 5 mr/hr radiation level reported 400 miles southwest of GZ during a weather reconnaissance mission on plus one day. The middle level of the cloud (20,000 to 60,000 feet) moved to the east-northeast at a speed of 15 knots. Several contacts were subsequently made with fall-out from this segment (see Appendix I). Between plus 5 and plus 7 hours the trailing edge of such an area was clearly defined by one of the cloud tracker aircraft (see Appendix II); maximum intensities of 2 r/hr were reported 200 miles east-northeast of BIKINI. The highest or mushroom level moved initially to the north and west. In the fall-out process, however, the debris was carried back to east where several interceptions were made. The first was at plus 15 hours, when a tracker aircraft was able to completely delineate a fall-out area which was centered 300 miles to the east-northeast of GZ; the maximum reading inside this area was about 500 mr/hr above aircraft background. At this same time another cloud tracking aircraft located contamination of 6 r/hr in this same general area (80 NM north of BIKAR Atoll) but at an altitude of 1,500 feet.

3. SAMPLING AIRCRAFT REPORTS:

As in the case of previous shots, these reports were recorded by Radsafe personnel aboard the Command Ship from plus 2 to plus 5 hours. Reports from these aircraft provided the first data available on initial cloud movement and confirmed the accuracy of the forecast air RADEX (see Appendix III).

4. SWEET-SOUR REPORTS:

These reports were submitted by any aircraft encountering radioactive contamination and not reporting by other means. No such reports were received following YANKEE.

5. SPECIAL CLOUD TRACKING (WILSON) FLIGHTS:

a. The initial phases of the YANKEE cloud tracking effort duplicate those which were so successfully employed for previous CASTLE shots. Two WB-29's, Wilson 2 and Wilson 3, were placed in a holding pattern 50 miles west of GZ at plus 2 hours. As will be seen from Appendix I, the location and orientation of this pattern is such that any cloud segments moving toward either ENIWETOK or UJELANG should be intercepted by at least one of these aircraft.

b. As in the past, Wilson 2 orbited in the racetrack pattern west of

GZ at 10,000 feet from plus 2 to plus 5 hours. During this period the first significant radiological contact was made at 2205Z (plus 4 hours) at a point 55 miles west-southwest of BIKINI. Within minutes the intensities climbed to a peak value of 63 mr/hr. This portion of GILDA (the atomic cloud and its fall-out) obviously had as its source the lowest level of the stem. It is likely that none of this debris had its origin at an altitude in excess of 18,000 feet. Both the position of this intercept and the time of arrival agree well with the pre-shot forecasts. This segment subsequently continued its southwesterly movement passing to the south of ENIWETOK. On YANKEE plus one day a weather reconnaissance aircraft, PETREL NECTAR, located fragments of this part of GILDA 400 miles southwest of GZ. At plus 5 hours Wilson 2 passed to the north of the shot atoll enroute to his search sector to the east Upon reaching a point 50 miles east-northeast of BIKINI, this plane began overtaking the trailing edge of GILDA. By 2325Z penetration of this area had been carried to the point where intensities of 1.8 R/Hr were being obtained. At that time a turnout was executed to the south and then east. One hour later the plan steered north and once again began probing for the southern edge of the cloud. This series of maneuvers indicated that this aircraft crew clearly understood their objective, which was to define the limits of GILDA rather than to seek out maximum fallout. At 0112 Zebra (plus seven hours) 190 miles east-northeast of BIKINI the radiation intensities quickly climbed to 1.8 R/Hr above background. On the basis of the foregoing interceptions it was possible to plot the position of the souther or trailing edge of GILDA (see Appendix II). The leading or upwind edge, shown as a broken line, is a predicted limit and was obtained by applying the appropriate wind vectors to determine the path of a particle originating at sixty thousand feet on the downwind edge of the mushroom. This altitude choice was made since the time and position of these contacts is such that these particles must have begun their travel at an altitude of fifty to sixty thousand feet. If this hypothesis is correct, then this particular debris was falling at an average speed of eight thousand feet per hour which, in turn, represents a fairly large particle. Follwoing this encounter with GILDA, WILSON TWO again turned south and east. Subsequent reports by this aircraft were assessed as background resulting from previous interceptions. The marked drop in intensities reported after 0600Z are due to the fact that an instrument failure necessitated the subsequent employment of a less sensitive radiation meter.

c. At approximately 2010 Zebra (plus two hours) a dense cloud was reported in such a position that it might cause fallout on the Task Force fleet (south of BIKINI) if it were composed of YANKEE debris. To investigate this potential hazard WILSON THREE was requested to leave the holding pattern and proceed at six thousand feet to a point twenty miles southeast of NAN (ENYU ISLAND). This vector was given in an effort to define the southern edge of the YANKEE cloud and its fallout. Thereafter the aircraft was requested to descent to five hundred feet and make a survey of the southern islands of BIKINI ATOLL and the airstrip in particular. WILSON THREE encountered no radiation during the first phase of this twofold mission; a fact which proved that the cloud over the fleet was of natural origin and thus constituted no hazard. At five hundred feet over NAN, however, intensities of 2 R/Hr were reported. Over the airstrip the levels were lower but varied over a considerable range (600 - 850 Mr/Hr). Subsequent helicopter surveys established the fact that the fallout was actually a small fraction of the intensities encountered by WILSON THREE during his survey. This ambiguity appeared, however, to be another example of a phenomena first observed during CASTLE when high-yield devices were detonated aboard a barge. In those cases it appeared that a certain amount of the radioactive debris was in the form of an aerosol-like suspension. The finely divided radioactive particles which comprised a part of this suspension appeared capable of remaining airborne for long periods. As a result such aerosols were capable of drifting along a very few feet off the surface and yet left almost no fallout. One rather spectacular example was the case where small flags flying just over rather efficient fallout collectors adsorbed many times the amount of debris deposited in the collector itself. Many other instances could be cited which tend to support the case for the existence of such an aerosol. Accordingly, it was believed that the "high transient intensity - low fallout" observed at NAN and the airstrip were due to just such a mechanism. Following the NAN and airfield survey, WILSON THREE continued to fly in the immediate vicinity of Ground Zero. The maximum intensity reported during the remainder of the mission was 4 R/Hr over BIKINI ISLAND at 2103 Zebra. Thereafter the aircraft background was approximately 1 R/Hr so the crew was instructed to return to base.

d. As soon as it was determined that WILSON THREE would be released the unit commander was requested to furnish a replacement aircraft to be designated as WILSON FOUR. This plane reported in the holding pattern at six thousand feet at approximately 0100 Zebra. About thirty minutes later this tracker reported a single contact of 30 Mr/Hr, fifty miles west of Ground Zero. It is believed that this was fallout from the mushroom. From the character of the low-level winds, it appeared desireable to conduct a shot-day atoll survey similar to that for UNION. The necessary instructions were passed to WILSON FOUR, who departed immediately for WOTHO, the first atoll to be surveyed. The results of the entire atoll survey are tabulated in Appendix I (atoll locations can be determined by comparing the time of survey with the position plot). This data showed that no significant fallout occured on YANKEE day on the atolls south of an east-west line through Ground Zero. The light fallout which was observed subsequent to that time on almost every nearby atoll was almost certainly material from the upper level of the cloud. Since this debris fell slowly it was very widely dispersed, and eventually small, spotty traces of this material could be found throughout the Marshall Island area. After reaching the northwestern extremity of the atoll area, WILSON FOUR climbed to fifteen hundred feet and continued north. At 0750 Zebra (plus 14 hours) a radiation level of 1 R/Hr was encountered fifty miles north of BIKAR. Seven minutes later the intensities had climbed to 6 R/Hr. The plane crew executed a turnout to the south and then returned to base. Study of the data available indicated that this debris must have had its origin in the mushroom in which case continued fallout brought this contamination to surface in the open ocean areas between BIKAR and BIKINI. Subsequent reports by this aircraft were believed to be background.

e. WILSON FIVE departed ENIWETOK ISLAND at approximately YANKEE plus twelve hours with the mission of conducting an area search out to maximum range between true bearings of 40 and 70 degrees from Ground Zero at an altitude of ten thousand feet.

Enroute to the designated area intermittent contacts were made with some of the generalized contamination which has been discussed previously. Beginning at 0802 Zebra (plus 14 hours) and continuing to 1534 Zebra (plus 21 hours) WILSON FIVE began the systematic probing of a very large radioactive area which appeared to fallout from the mushroom (above sixty thousand). In this case a fairly complete set of data was obtained from which the contamination limits could be fixed with considerable confidence. A diagram of this area is attached as Appendix II. All positions and intensities are extrapolated to 0900 Zebra for this purpose of this plot. Although the data is hardly sufficient to warrant such refinement, isodose lines have been drawn on a "best approximation" basis. From this plot it will be seen that the most intense fallout covered an area of approximately fifteen hundred square miles and was centered 300 miles east-northeast of BIKINI. The maximum reading inside this area was 500 Mr/Hr. The 20 Mr/Hr isodose line encompassed in excess of twenty-five thousand square miles; this clearly indicates how quickly large areas may be threatened by fallout. All this mass of contamination was at that time being carried back toward BIKINI by the "easterlies" prevailing below fifteen thousand feet. Although it seemed certain that continued fallout and dispersion would dissipate the hazard, it was recommended that the Task Force elements at BIKINI be advised of the presence of a large mass of contamination in an upwind direction. This was accomplished. In addition an attempt was made to give WILSON FIVE a vector which would insure that a survey was made of this air parcel subsequent to the time fallout should have been complete and prior to its arrival at BIKINI. Unfortunately communication difficulties negated this effort. Subsequent surveys by other means established the fact thatno significant fallout occurred after shot day, hence the scavenging mechanisms must have functioned as expected. Enroute to base WILSON FIVE passed through a rainshower reducing the background reading from 300 to 70 Mr/Hr, which was another indication of how effective rain can be as a decontaminating agent.

f. Subsequent WILSON flights for YANKEE were cancelled.

6. WEATHER RECONNAISSANCE FLIGHTS:

Two weather reconnaissance flights were flown on YANKEE plus one day. The first of those, PETREL NECTAR, was flown to the north and the west of Ground Zero. During the course of this flight three brief encounters were made with spotty radiation. A second flight, PETREL METRO, flown to the south and east intercepted similar fragments. In all except one case the intensities were not in excess of 10 Mr/Hr and are believed to be a part of the generalized contamination that follows a high-yield detonation. The single exception was the contact at plus thirty-eight hours, 110 miles east-northeast of Ground Zero, where the intensity was 40 Mr/Hr.

7. AFOAT-1 FLIGHTS:

AFOAT-1 sponsored flights made radioactive sample collections of YANKEE debris at several remote locations. In all cases the debris was found to be widely despersed throughout the general area, but, as one would expect, the levels were quite low ranging from a few Mr/Hr to a small fraction of that amount. The results of these collections are tabulated below.

ZEBRA TIME		ALTITUDE	COUNTS/MIN/HR in millions
06/1400 (Plus 44 hours)	14N 162W to 13N 161W (150 Mi southwest Hawaii)	18000	60
07/0110 (Plus 55 hours)	13N 161W to 15N 160W (130 Mi southwest Hawaii)	15-17000	117

8. CONCLUSIONS:

a. The Air Rad Safe operations for YANKEE were quite successful. In particular the cloud tracking operations were such that fallout areas could be delineated with more assurance than on any previous CASTLE shot.

b. There were no elements of the YANKEE cloud or its fallout which necessitated the evacuation of nearby atolls.

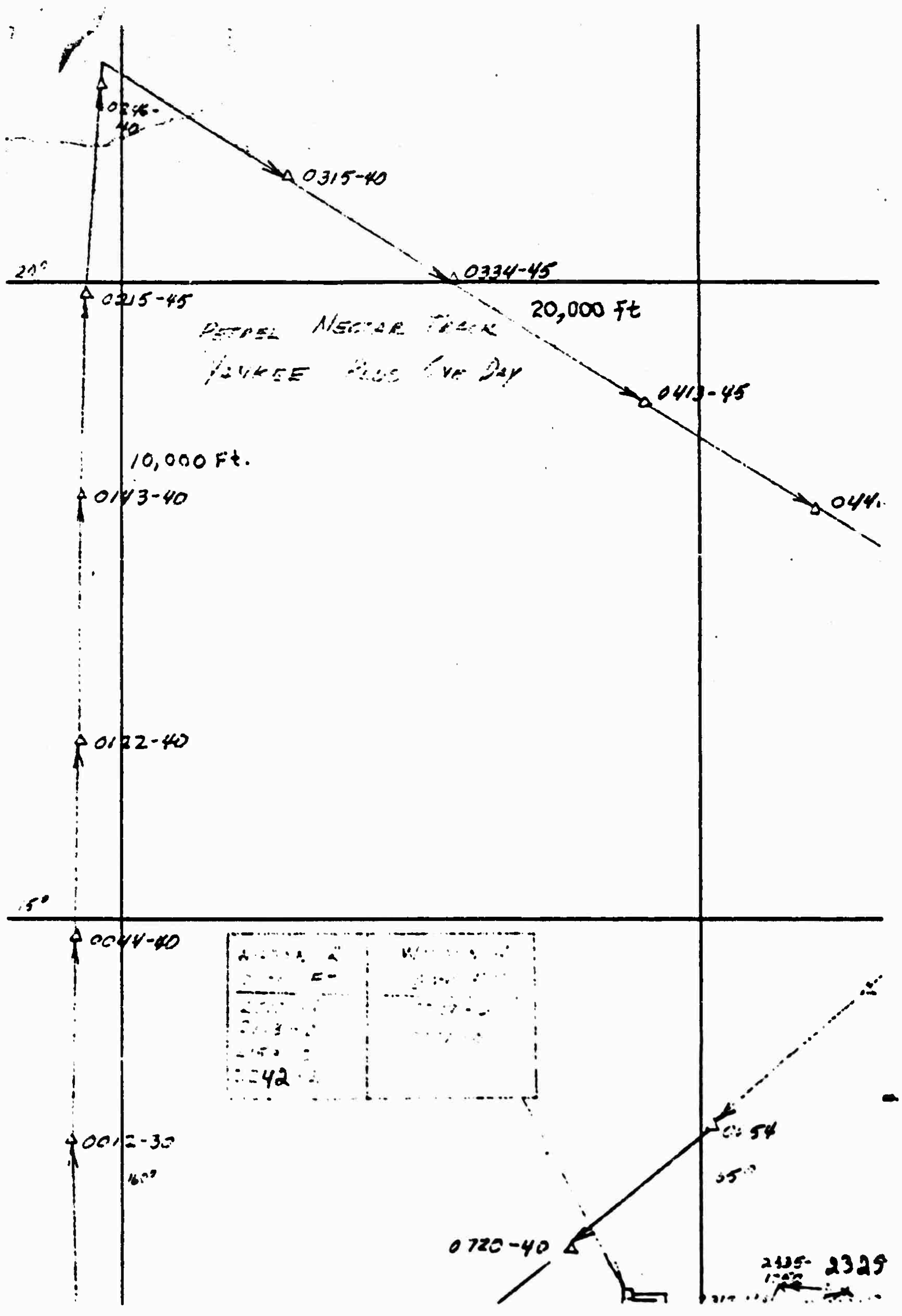
c. The use of WB-29 cloud tracker aircraft as a means for making a preliminary survey of the populated atolls to the southeast of Ground Zero again proved practical.

d. There was no evidence which indicated that hazardous fallout likely outside the immediate area of Ground Zero other than the few cases mentioned in this report where fallout took place over the open ocean. Fallout outside the PPG was forecast to be slight and of no consequence from the health point of view.

9. RECOMMENDATIONS:

None.

3 Appendices
I - WILSON A/C Plot (A and B)
II - Fallout Plot
III - YANKEE Air Radex


0315-40
0334-45
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0413-45
10,000 Ft.
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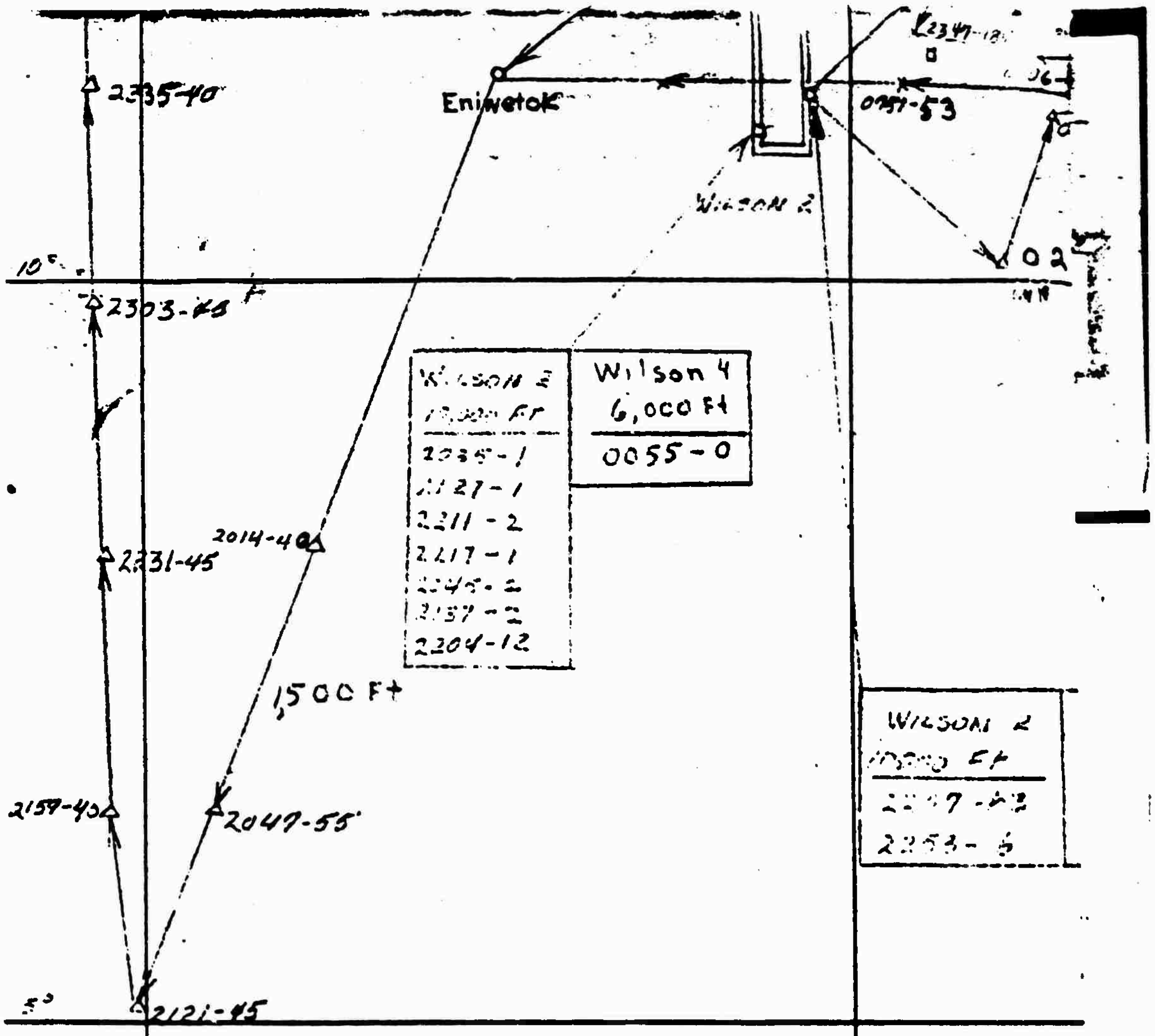
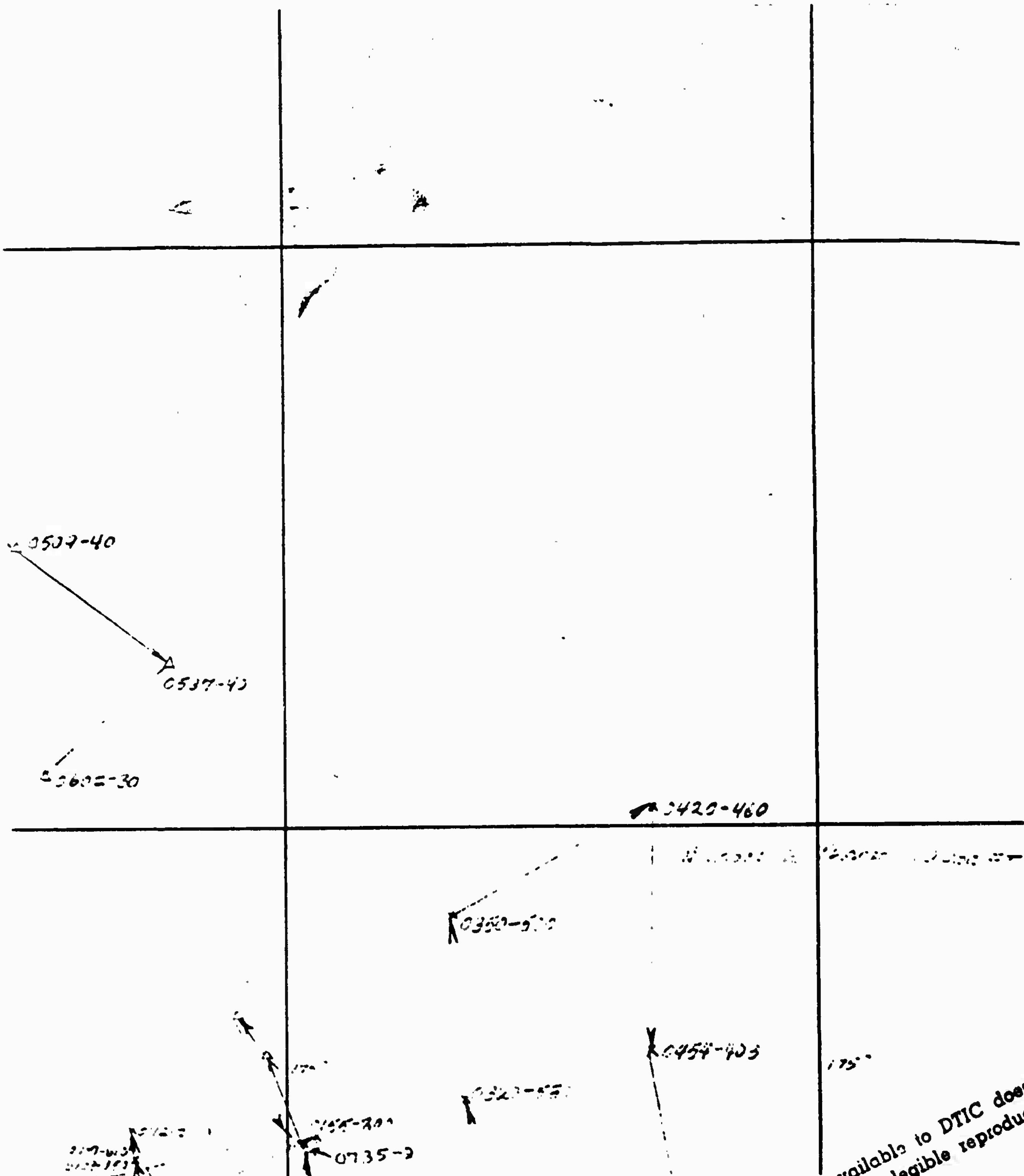
0122-40
0044-40
0720-40
2329

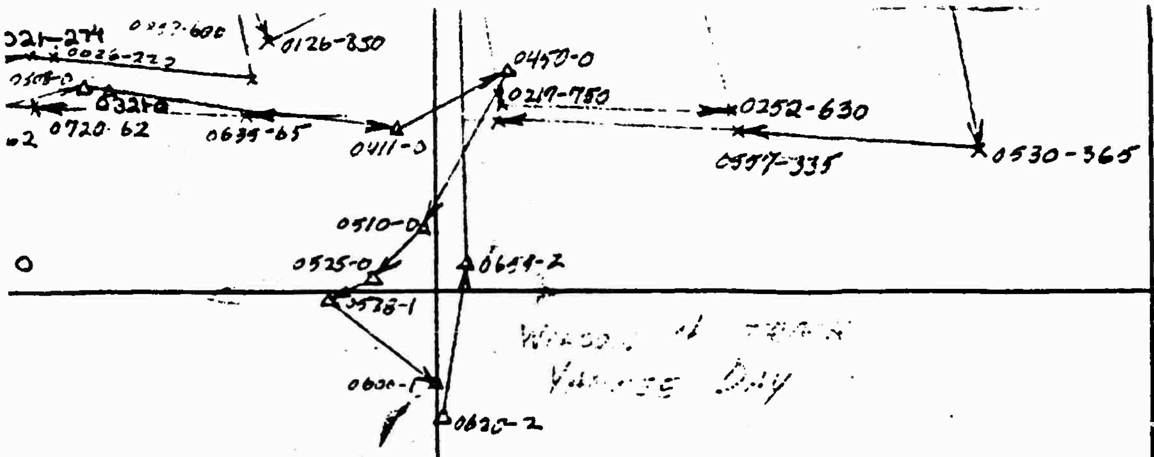


YANKEE DAY ATOLL SURVEY BY WILSON 4

ATOLL	TIME	READING	ALTITUDE
Wotho	0213	0 MR/HR	100 FEET
Ailinginae	0247	0	200
Rongelap	0308	0	200
Rongerik	0321	0	200
Taka	0411	0	200
Uterik	0429	0	200
Mejit	0450	0	200
Ailuk	0510	0	200
Jemo	0525	0	300
Likiep	0538	1	200
Wotje	0600	1	200
Erikub	0620	2	200

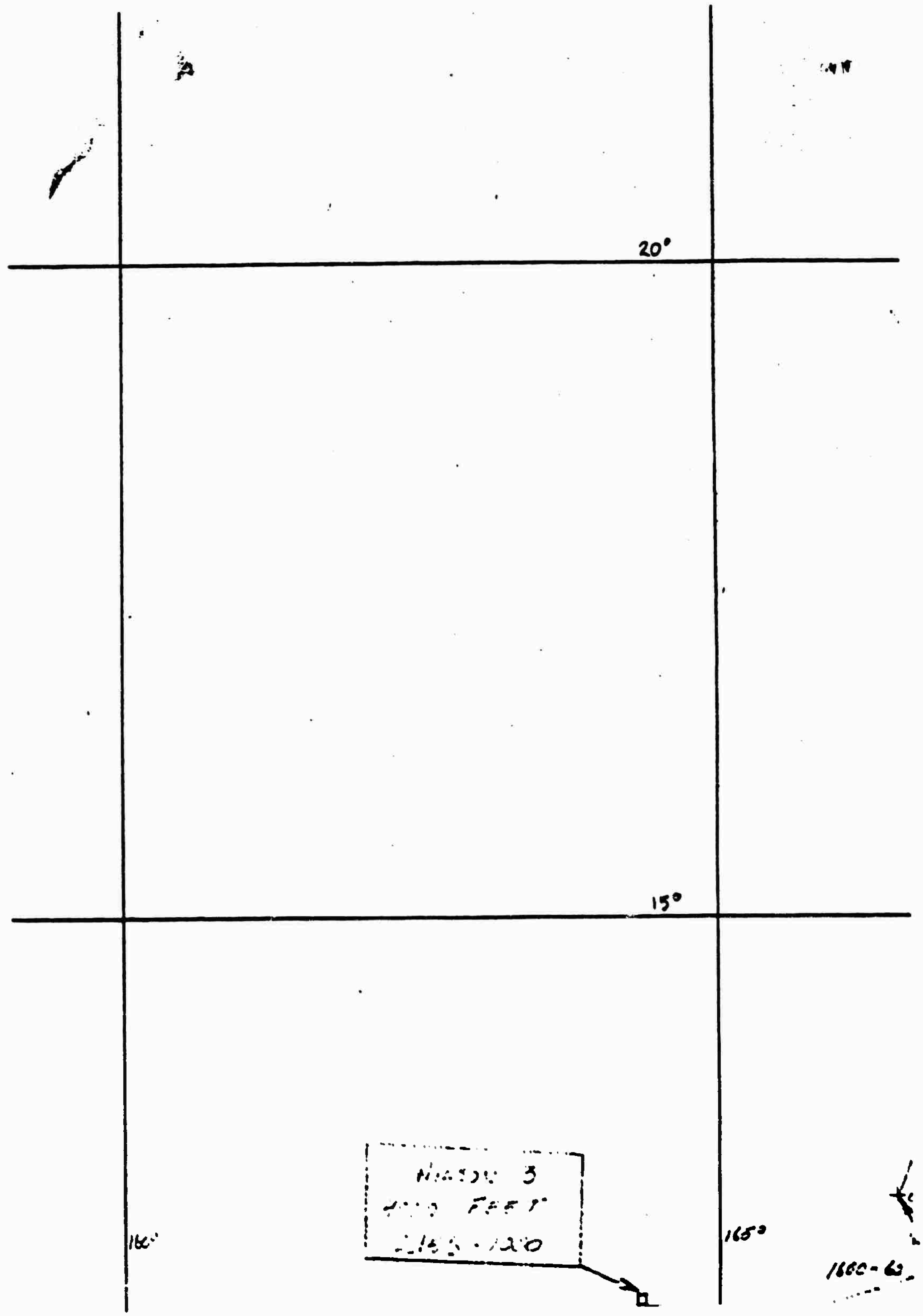
Y

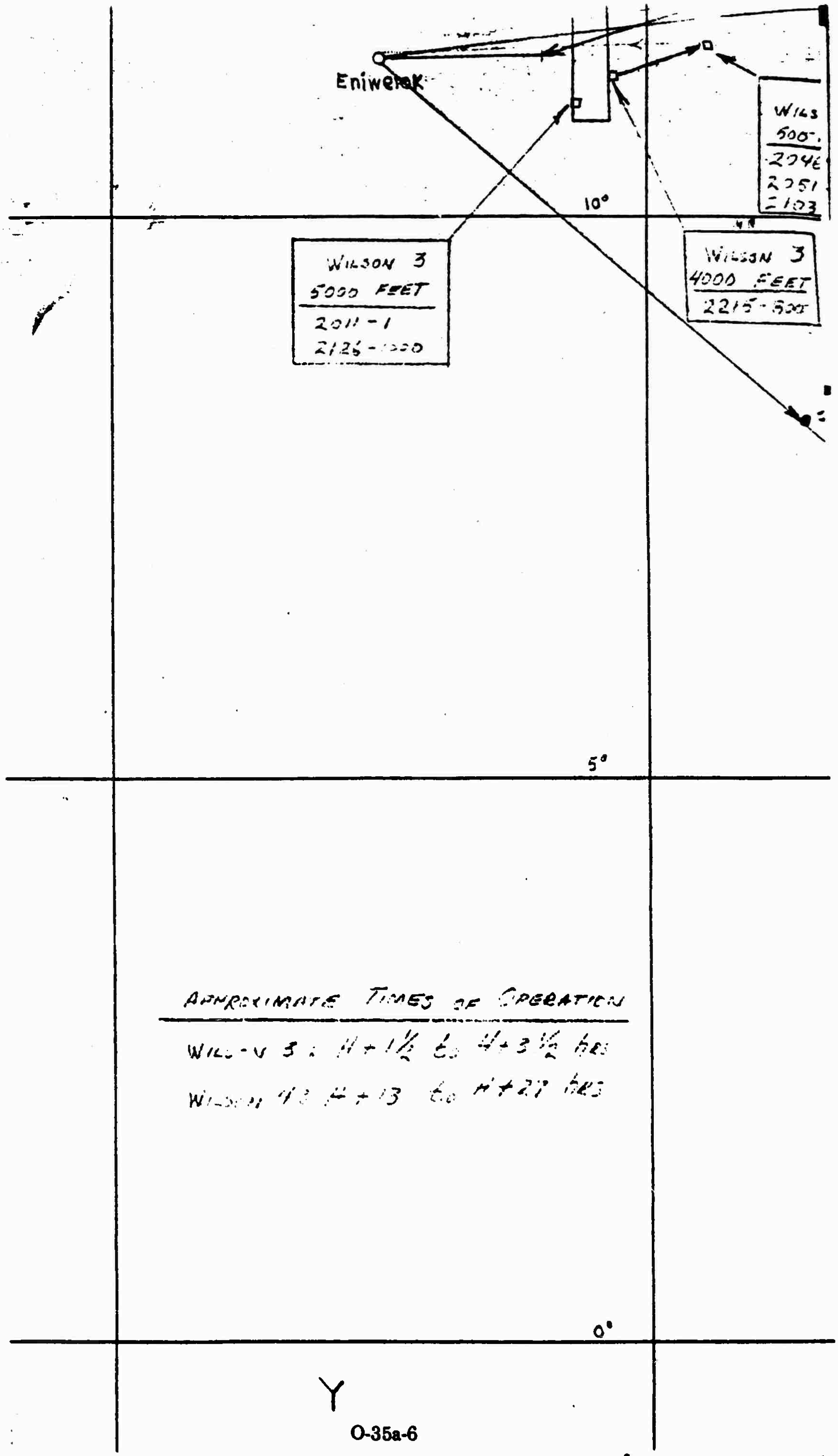


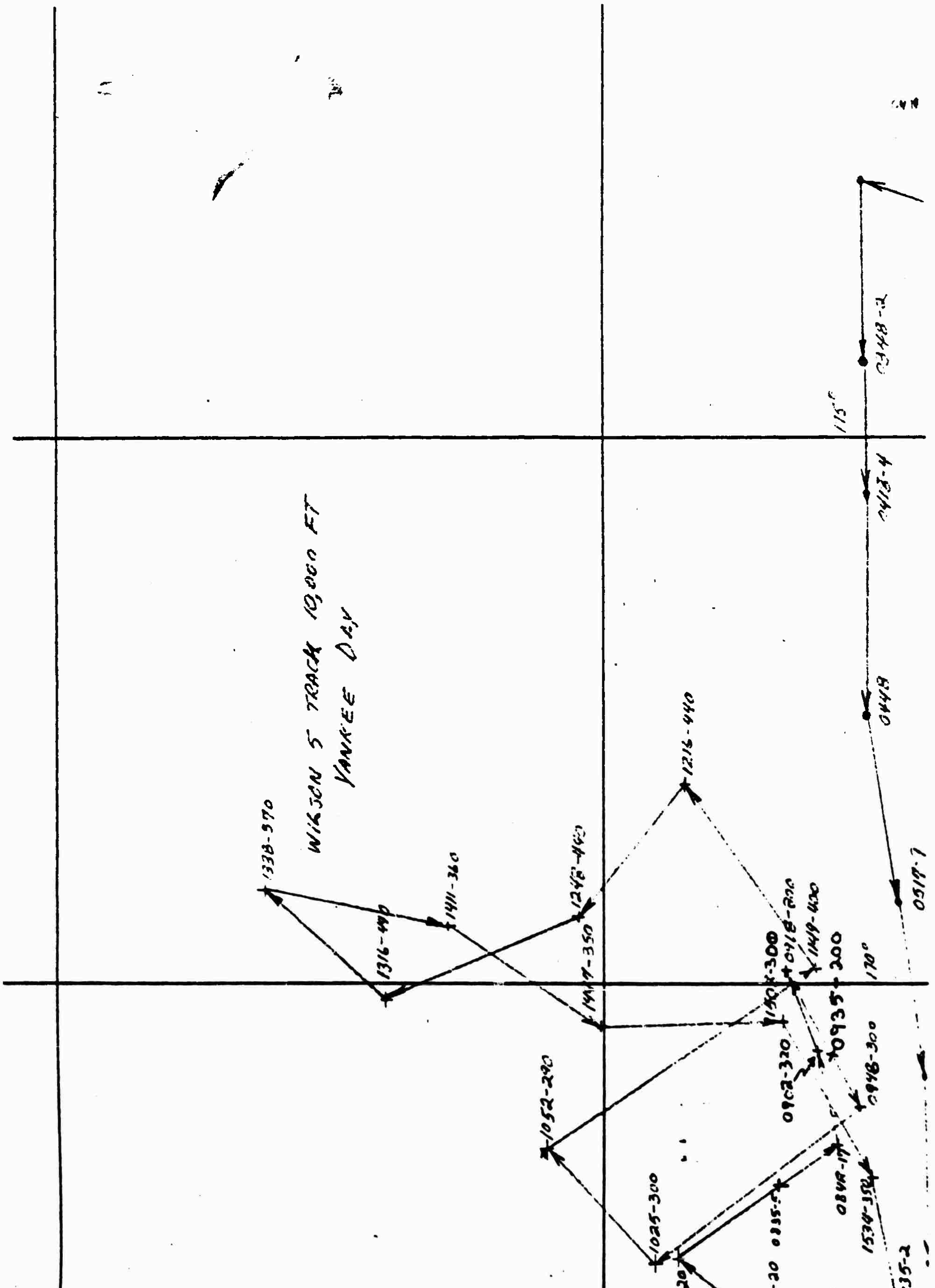


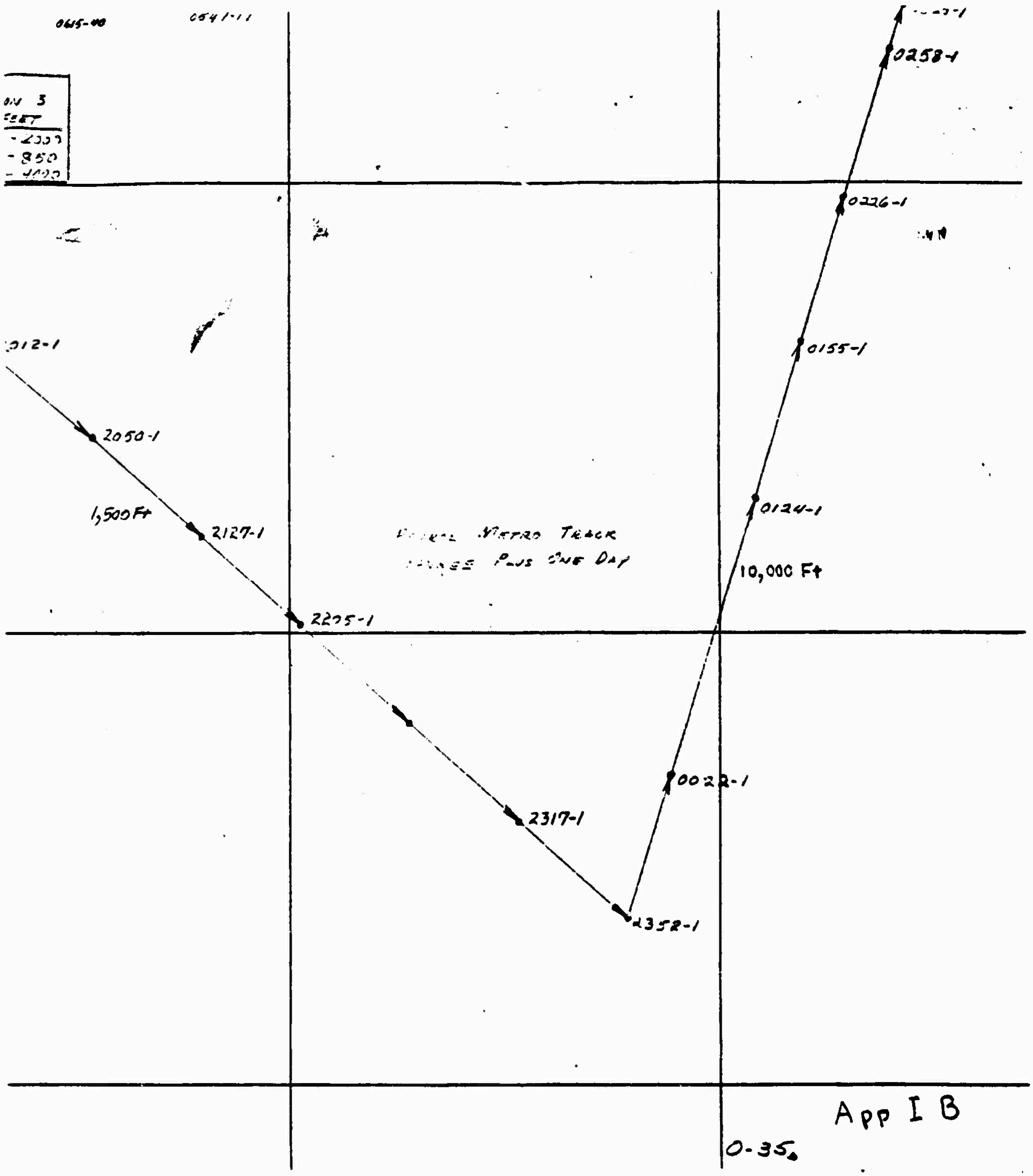
(Readings Include Aircraft Background)

A


20°
15°
165°
FEET

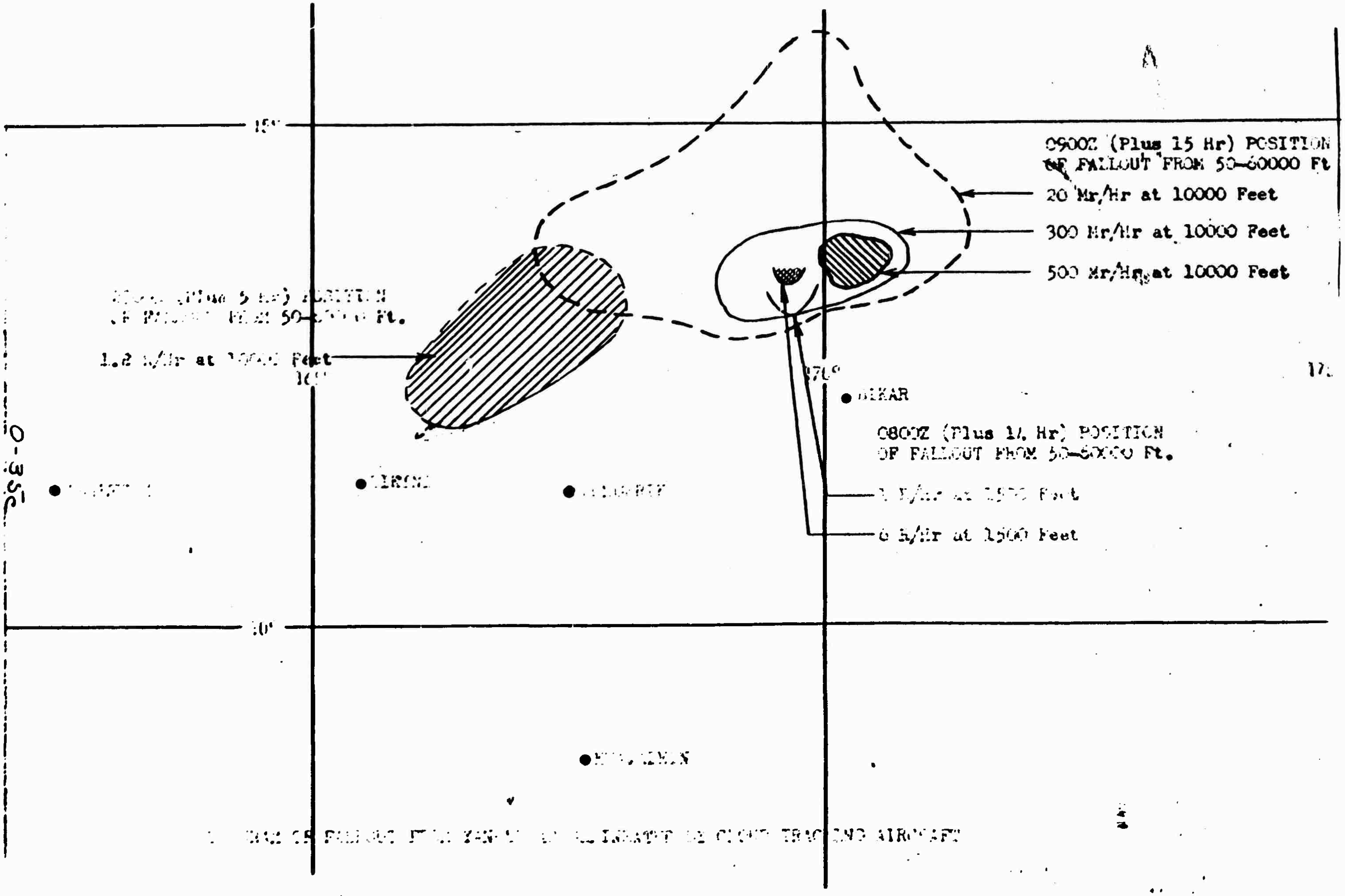

Eniwetok
WILSON 3
5000 FEET
2011-1
WILSON 3
4000 FEET
10°
5°
0°
APPROXIMATE TIMES OF OPERATION
Y


WILSON 5 TRACK 10,000 FT
YANKEE DAY



0615-40
0541-11
3
FEET
-2300
-850
-4000
2012-1
2050-1
1,500 Ft
2127-1
2225-1
2317-1
2352-1
0022-1
0124-1
10,000 Ft
0155-1
0226-1
0258-1
Metro Track
Plus One Day
0-35

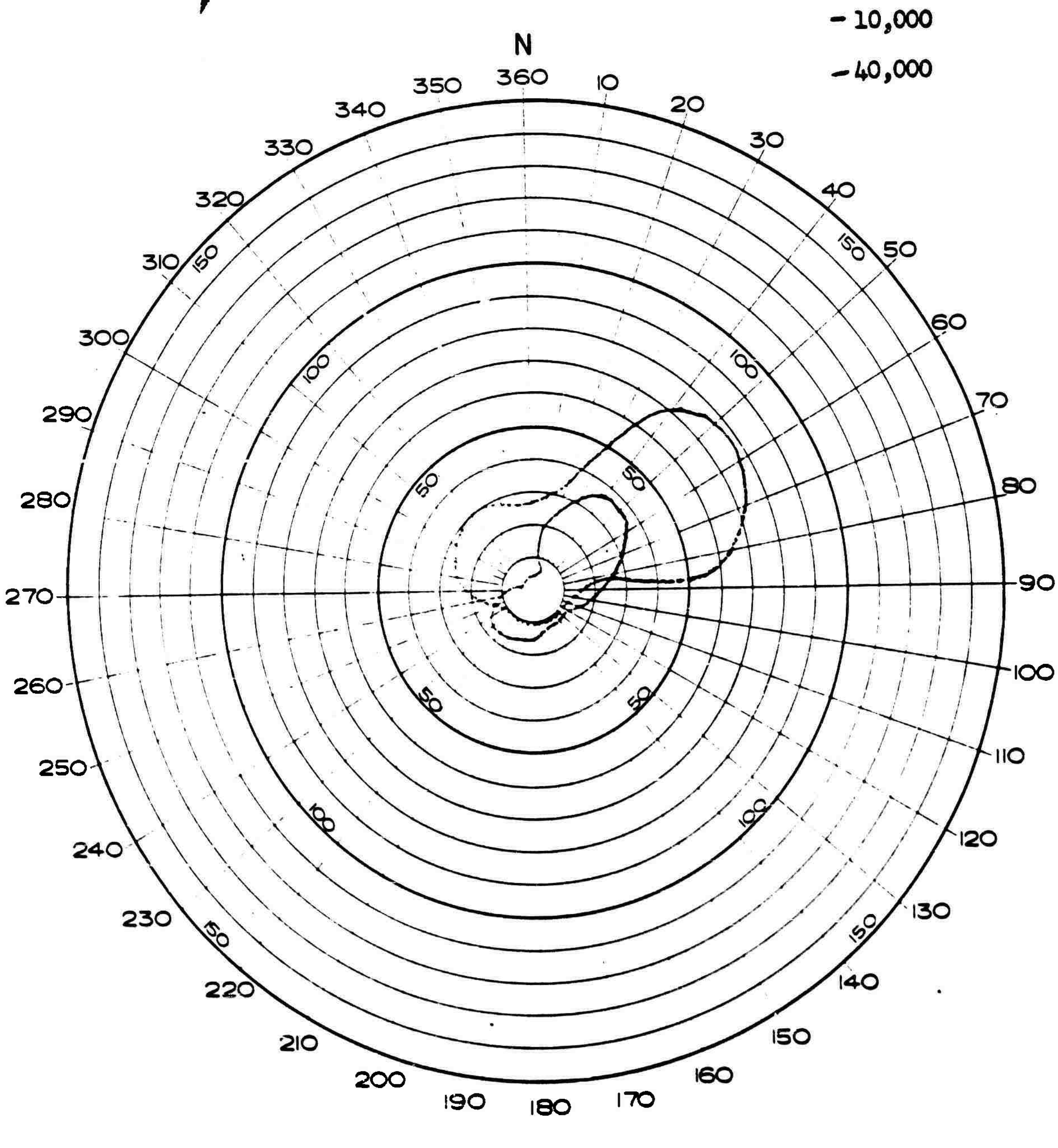
App I B


0900Z (Plus 15 Hr) POSITION
OF FALLOUT FROM 50-60000 Ft
20 Mr/Hr at 10000 Feet
300 Mr/Hr at 10000 Feet
500 Mr/Hr at 10000 Feet
0800Z (Plus 14 Hr) POSITION
OF FALLOUT FROM 50-60000 Ft.
6 R/Hr at 1500 Feet
1.2 R/Hr at
Feet
BIKAR
170°
15°
10°
CLOUD TRACKING AIRCRAFT

0-35c

HODOGRAPH

RESULTANT WINDS AND SURFACE RADEX



YANKEE AIR RADEX FOR YANKEE PLUS ONE HOUR

D-35a

PRELIMINARY RESULTS

NYKOPO AIRBORNE MONITORING SURVEY FLIGHTS O/A 5 MAY 1954
(Conducted by Health and Safety Laboratory, New York Operations Office, AEC)

LOCATION (Atoll unless otherwise indicated)	LOCAL TIME (May)	MAXIMUM GROUND INTENSITY (in mr/hr)	LOCAL TIME (May)	MAXIMUM GROUND INTENSITY (in mr/hr)	LOCAL TIME (May)	MAXIMUM GROUND INTENSITY (in mr/hr)
FLIGHT ABLE						
KWAJALEIN	061455	0.4	071800	4.5*	081335	0.2
LAE	060830	0	070822	1.2	080726	0.1
UJAE	060845	0	070832	0.8	080737	0.16
WOTHO	060912	0.08	070857	1.6	080810	0.2
AILINGINAE	061024	0.8	071005	10.0	080916	1.2
RONGELAP Is.	061038	8.0	071019	30.0	080928	6.5
RONGERIK	061052	3.0	071033	21.6	080943	4.0
TAONGI	061215	0.2	071151	0.2	081111	0
BIKAR	061315	15.0	071247	34.0	081203	4.0
UTIRIK	061335	0.8	071318	6.0	081223	1.2
TAKA	061340	0.8	071312	5.6	081226	1.5
AILUK	061400	0.2	071330	0.7	081245	0.7
JEMO	061410	0.2	071339	3.2	081245	0.3
KIKIEP	061415	0.2	071346	3.2	081302	0.5

*Ground observation

MAXIMUM GROUND READINGS OTHER NYKOPO FLIGHTS (IN MR/HR)

FLIGHT BAKER (9 May): 1.7 at WOTJE; next highest 0.3 at ANI

FLIGHT CHARLIE (9 May): 0.2

FLIGHT EASY (12 May): 0.6

SUMMARY OF THE STATUS OF TRANSIENT SHIPPING IN THE PPG AREA O/A 5 MAY 1954

1. Task Force sources of information:

a. LST's 762 and 975 approximately 650 NM east northeast of GZ at H-Hour, enroute to PEARL.

b. USS NAVASOTA arrived KWAJALEIN 050735M, ETD for MIDWAY 5 May.

c. USS SHEA arrived KWAJALEIN 041900M, ETD for PEARL 5 May.

d. USS LEO (T-AKA-60) and USS AREQUIPA (AF031) at ENIWETOK 041200M.

e. USS RECLAIMER (ARS-42) departed BIKINI to GUAM 041200M via 10-40N, 165-10E, 10-40N, 155-00E, SOA 11 knots, ETA GUAM 091800M.

f. Contact from search aircraft 042000M, 1 DD, 10-45N, 162-54E, course 190 True, radar contact.

g. Contact from search aircraft 042030M, 1 DD 10-31N, 165-51E, course 150 True, SOA 10 knots, visual contact.

2. COMNAVFORMARIANAS source of information:

a. M/V Roque, PacMicronesian Line vessel departed area 27 April, 5 May position Rota.

TAB "P"

NECTAR

NECTAR had been ready for firing since 22 April, (detailed pre-shot actions were completed for firing on 4, 5 and 11 May) however, no wind pattern acdeptable at ENIWETOK materialized until 14 May. During this time the task force and operational plans were geared to a split-atoll type operation, simultaneously maintaining the capability of firing at either atoll. This was the first instance of such flexibility in U.S. testing history and quite indispensable to the CASTLE operation in view of the long shot delays chargeable to unfavorable winds. Wind patterns with southerly components were rare at ENIWETOK during this period, and when present, lacked strength and depth. The risk of contaminating the PARRY and ENIWETOK Island camp sites was the prime deterent to acceptance of the marginal southerly patterns available prior to 14 May. In the meantime YANKEE was detonated at BIKINI on 5 May, leaving only the NECTAR shot to complete the test series. On the morning of 13 May a shift in the winds (above the lower trades) from northerlies to southerlies was predicted for the 14th. By noon the forecast appeared promising enought to formulate a firm decision to designate 13 May as NECTAR minus one day. During the afternoon appropriate advisories were issued to task force and external agencies. CINCPACFLT was advised of the scheduled shot time of 140620M, the forecast 72-hour air particle trajectories for ten, twenty, thirty and fifty thousand foot and the fact that no significant fallout was forecast for populated MARSHALL Islands. It was recommended that no air routes be closed, and a statement was issued to the effect that no health hazard problem existed for surface routes outside Area EVELYN. The advisory further stated that an intensive pre-shot search was being conducted in Area EVELYN, and that a post-shot sector search would be made if required. CINCPACFLT was requested to divert all shipping outside the previously designated 450 NM Danger Area and was informed that no known transient shipping was in this area. (The need for a post-shot sector search proved unnecessary.)

Area EVELYN had been designated approximately 1 May when it became obvious that daily searches of the entire Area GREEN were placing a drain on aircraft availability due to repeated shot delays and the consequent wasted search efforts. Area EVELYN was defined as a semi-circular sector of 300 NM radius to the north of an east-west diameter through the center of ENIWETOK Atoll plus a 60 by 600 NM east-west strip centered on and to the south of this diameter. This area was well within the capability of three search aircraft operating out of KWAJALEIN and could be covered with an "Execute order" issued late in the pre-shot preparations and with less probability of "false start". Search results for NECTAR were negative.

A special advisory was issued to the British Sampling Unit at KWAJALEIN giving the scheduled shot time, the forecast 72-hour air particle trajectories, the forecast area for British operations, authority to penetrate the Danger Area, and instructions to file flight plans throught the KWAJALEIN Liaison Officer using the advisory as authority for NECTAR flights. Information was included to the effect that final route and scramble instructions would be issued separately at H plus 2½ hours.

The forecast Surface and Air RADEXES were issued as follows:

Surface RADEX: True bearings from GZ 250° clockwise to 80° radial distance 60 NM for H to H plus 6 hours plus a circular RADEX around GZ of 10 NM radius.*

Air RADEX: H plus 1 hour, 10,000 feet and up (true bearings from GZ):

275° clockwise to 30° maximum distance 15 NM
30° clockwise to 100° maximum distance 35 NM
100° clockwise to 275° maximum distance 5 NM

40,000 feet and up (true bearings from GZ):

240° clockwise to 330° maximum distance 25 NM
330° clockwise to 40° maximum distance 15 NM
40° clockwise to 110° maximum distance 60 NM
110° clockwise to 240° maximum distance 15 NM

H plus 6 hours, 10,000 feet and up (true bearings from GZ):

275° clockwise to 30° maximum distance 70 NM
30° clockwise to 100° maximum distance 180 NM

40,000 feet and up (true bearings from GZ):

260° clockwise to 300° maximum distance 70 NM
40° clockwise to 100° maximum distance 300 NM

An informal check of the weather and winds was made at approximately 1700M, conditions being such that previous decisions were confirmed. A formal complete command briefing was scheduled for midnight. As the evening weather observations progressed, it became more and more apparent that the southerly flow was developing and that sufficient warm moist air would be moved up from the south to produce significant shower activity in the shot area by H Hour.

Due to the proximity of UJELANG Atoll (120 NM southwest of ENIWETOK), it was decided to station a destroyer at UJELANG to stand by should unforeseen circumstances make an evacuation necessary. The cloud tracking plan had already been designated to place two cloud trackers in a racetrack holding pattern approximately 50 NM southwest of ENIWETOK to detect any movement of contamination toward UJELANG. The pattern of these trackers was oriented such that approximately two thirds of the pattern was north of a line between UJELANG and ENIWETOK in order that maximum advantage could be made in the detection of low-level contamination moving to the west and still keep UJELANG in the "shadow" of ground zero.

A complete Command Briefing was held at approximately 140030M. The winds and weather being favorable, it was decided to continue with the shot and to look at the forecast and observed winds again at approximately 0530M. The major fall-out pattern was predicted to lie along a general west southwest to east northeast axis and far enough north to miss the camp sites (See Inclosure 4). The new technique, based on forecast time and space changes in the wind pattern for H to H plus 24 hours, gave a similar fall-out pattern. It was predicted (by the method of Incl 3 to Tab D) however, that a small amount of contamination could possibly arrive at the camps. For this reason, it was decided that all task force ships would re-enter the lagoon and anchor at normal berths immediately after H hour and that all personnel be on alert to effect an emergency evacuation should such become necessary. However, due to increased depth of the southerly components which developed before and after shot time, no contamination was experienced on any island south of YVONNE.

At about H minus 6 hours an additional advisory was issued to the British Unit on KWAJALEIN, passing the latest forecast 72-hour air particle trajectories, the forecast GZ winds for H Hour and authority to penetrate the Danger Area in accordance with scramble and routing instructions to be issued post-shot by CTG 7.4.

Directives were issued for cloud tracker Wilson 2 to search from H plus 2 to H plus 14 hours in a modified racetrack holding pattern 50 NM southwest of GZ at 10,000 feet for three hours, thence to the sector centered on GZ with limiting true bearings of 65° and 95° at 10,000 feet. Wilson 3 was directed to search in the above holding pattern from H plus 2 hours until released and at an altitude selected by the pilot to clear natural clouds, but not in excess of 6,000 feet.

During the night frequent rain showers were experienced over the camp sites, but since the wind pattern was becoming more and more favorable, all preparations were continued and arrangements made through the weather station and the Air Force GCA unit on ENIWETOK Island to monitor all showers up to H minus 20 minutes. Provided no showers existed at shot time which would cut out essential experimentation, the shot could go on as planned.

The 0530M weather/radsafe check being favorable, and no transient ships contacted in Area EVELYN, all efforts were devoted toward getting the shot off on time. The GCA Unit reported the positions and movement of local showers, the latest being approximately 30 NM east of GZ at about H minus 20 minutes. Just prior to shot time a large shower occurred to the north of PARRY Island, apparently generated since the last GCA check. Since light transmission paths for the northern instrument sites appeared satisfactory (the shower apparently confined to the area between PARRY and GZ), the shot was detonated on a barge in approximately 100 feet of water in the IVY MIKE Crater (ELUGELAB Island, ENIWETOK) at 140620M as scheduled. Within 30 minutes advisories were passed to the Chairman, AEC, C/S Army and CINCPACFLT indicating the detonation and safety of task force personnel. Moderate rain showers persisted almost continuously throughout the shot day. Sampling aircraft reported that rain and cloud cover existed in layers from 2,000 feet up to 50,000 feet for at least the first six hours after shot time. The possibility of a hazard developing from the scavenging action of rain was considered, but seemed remote in view of the continual pre-shot and post-shot deepening of the layer of southerly winds. Also, NECTAR being the last shot of the series, the capability for rapid emergency evacuation and continual radsafe checks of the camp sites were the prime factors in the calculated risk taken for this shot.

Cloud tracking operations were as planned and routine in nature. Only token amounts of contamination were found on the WILSON 2 and 3 flights, and on WILSON 4 (30 degree sector search upwind from RONGERIK) from H plus 12 to H plus 24 hours. All remaining cloud tracker flights were cancelled. Since no contamination was detected moving toward UJELANG by noon of shot day, CTG 7.3 was advised that the destroyer on station at UJELANG could be released, The destroyer was requ sted to return to ENIWETOK by the direct route and to continue monitoring for radiation on the way.

Within three hours after shot time, all units were advised as to the radsafe conditions. The advisory, based on the initial damage survey, indicated all islands from YVONNE clockwise through LEROY and all air and water traffic south of a line through YVONNE and LEROY were declared Radsafe Unrestricted. Swimming was authorized at established beaches in the unrestricted region. All air and water traffic north of the above line was declared subject to radsafe control of the Radsafe CENTER, ELMER (TG 7.1). An exception was made to the effect that all "round robbin" flights which did not ever fly the restricted area at less than 1,000 feet could be made without radsafe clearance provided all personnel wore film badges.

At 1325M WILSON 3 was directed to search out to maximum range at an altitude not to exceed 8,000 feet between limiting true bearings 70° and 100°, and to conduct a minimum altitude survey of WOTHO if possible. (Subsequent survey of WOTHO at 1915M, 300 feet, indicated less than 10 mr/hr.)

In accordance with previous plans, NYKOPO Flight Able was scheduled for N plus 1 day and NYKOPO Flights Able, Baker and Charlie for N plus 2 days. Flight Able on N plus 1 day was directed to make in-flight reports at RONGERIK and LIKIEP. All Flights on N plus 2 days were directed to make in-flight reports over each atoll in the flight pattern.

In view of the initial radsafe survey of the islands indicating major contamination confined to only the northern gro ps and past experience with IVY IKE, the lagoon water sampling program was cancelled as unnecessary. (It should be noted that, due to the IVY experience, the emergency evacuation play of ship re-entry to the lagoon was not made contingent upon lagoon water sampling.)

In accordance with plan, CINCPACFLT was advised at 2000M on shot day of the current radsafe situation. This advisory consisted of the following: No significant change was made in the forecast 72-hour air particle trajectories, based on cloud tracking operations on N day all significant contamination was moving to the east northeast and well to the north of a line through ENIWETOK and BIKINI, no significant contamination was moving toward UJELANG, and confirmation was made of the NYKOPO Flights for Radsafe roll-up on N plus 1 day and N plus 2 days. On N plus 1 day the second 2000M advisory was dispatched to CINCPACFLT. This advisory indicated no changes in the 72-hour forecast and a preliminary report on NYKOPO Flight Able on N plus 1 day. This report indicated RONGELAP reading 10 mr/hr and RONGERIK 15 mr/hr on the ground; all other atolls Flight Able indicated less than 2 mr/hr.

On N plus 2 days, the third and final 2000M CINCPACFLT advisory was dispatched. This advisory indicated that CINCPACFLT would be further advised as circumstances required, and corrected the previous 2000M N plus 1 day information to the effect that RONGELAP and RONGERIK should have been reported as 1.5 mr/hr and all others less than 1 mr/hr on N plus 1 day. This advisory further stated that the N plus 2 day Able, Baker and Charlie maximums in mr/hr were 1.5, less than 1, and less than 1 respectively, that no further radiation hazard was forecast for the CASTLE series and recommended no further diversion of shipping for radsafe reasons. The Post-NECTAR report to CINCPACFLT on the status of ships and personnel doseages was submitted by CTG 7.3, indicating in general, no additional significant increases due to NECTAR.

A major effort was devoted on this shot by the AEC New York Operations Office and Project 2.5a to delineate the NECTAR fall-out pattern using the techniques developed on YANKEE shot. The final reports of these two agencies are suggested as additional information on the long-range aspects of NECTAR and for possible extrapolation of the effects of rain as a scavenging agent.

8 Incls:

1. An Evaluation of Weather Forecast for NECTAR
2. Tabulation of NECTAR Pre-shot and Post-shot Winds from Task Force Stations
3. Forecast and Computed NECTAR Air Particle Trajectories
4. NECTAR Ground Zero Hodographs
5. NECTAR Shot Day Ground Radiation Intensities On-site
6. Air Radsafe Operation for NECTAR
7. Preliminary Results of NYKOPO Airborne Monitoring Survey Flights o/a 14 May 1954
8. Summary of the Status of Transient Shipping in the PPG area o/a 14 May 1954

AN EVALUATION OF WEATHER FORECASTS FOR NECTAR

1. Summary of weather immediately prior to N-Day: On the morning of N minus-one, the synoptic situation was described as follows: At 10,000 feet a clockwise vortex was passing to the north of ENIWETOK, keeping the winds light with southeasterly components. At 20,000 feet a shear line which had been south of the area had moved north of the area giving light southerly winds. At 30,000 feet, a small clockwise vortex was passing south of the station toward the east resulting in west-southwesterly flow. At 40,000 feet a clockwise outdraft near PONAPE was building, giving west-southwesterly flow.

2. The Weather Forecast: 5/8 cumulus, base 1800 feet, tops 8000 feet, scattered tops to 12,000 feet; 4/8 altostratus in thin patches, bases 15,000 to 25,000 feet; 7/8 cirrus, base 38,000 feet, tops 42,000 feet; light showers.

a. Observed weather: (based on observations taken by all personnel of the WCEP) 3/8 cumulus, base 1800 feet; 4/8 to 5/8 stratocumulus, base 3500 to 4000 feet; 6/8 cirrus, base 38,000 feet. No showers were observed at ENIWETOK at shot time, however, showers occurred four hours prior to shot time and within one hour following the shot. In all, 1.06 inches of precipitation fell on 14 May.

b. Comments on weather: Wilson flights (reconnaissance aircraft near shot site) north of ENIWETOK reported a broken condition of stratocumulus with tops at 4000 feet and a high cirrus overcast. By 1800Z the stratocumulus coverage decreased but had developed vertically, some tops being reported at 22,000 feet; the cirrus layer had decreased and become very thin and scattered. This description is based upon continuous and careful observation, wherein no difficulty was encountered to compromise accurate observations. Following the detonation, Wilson 2 and Wilson 3 reported considerable shower activity; 2/8 to 5/8 cumulus and stratocumulus, with tops rangin from 3500 to 9000 feet; a broken condition of altostratus, base 13,000 feet; and an overcast of cirrostratus, base 40,000 feet.

3. The Wind Forecast:

HEIGHT (Thsds Ft)	H-24	H-14	H-8	H-4	OBSERVED ENIWETOK H-HOUR
90	090/50	090/60	090/60	090/60	
80	090/40	090/50	090/50	090/50	
70	090/30	090/30	080/40	080/40	
65	090/20	090/20	120/20	120/20	
60	270/18	080/10	030/08	030/08	
55	260/36	280/40	290/30	290/30	290/38
50	270/45	270/45	270/45	270/40	280/35
45	260/35	260/40	260/50	260/45	230/32
40	260/27	250/40	250/38	240/35	210/24

Incl: 1

HEIGHT (Thsds Ft)	H-24	H-14	H-8	H-4	OBSERVED ENIWETOK H-HOUR
35	250/18	250/35	240/35	230/30	210/09
30	250/10	250/25	260/20	260/20	230/17
25	220/11	240/12	240/10	240/10	190/06
20	Lt&Var	220/05	200/06	200/06	130/08
18	Lt&Var	170/05	170/05	170/05	140/12
16	Lt&Var	160/03	110/10	130/12	130/12
14	090/07	120/05	120/10	130/15	110/18
12	080/10	110/08	120/10	130/15	120/17
10	090/18	130/18	120/08	120/08	110/14
08	110/11	110/11	110/10	110/10	100/10
06	110/18	110/18	100/20	100/20	110/14
04	110/20	100/20	090/25	090/25	110/19
02	090/22	090/22	090/22	090/22	100/17
SFC	090/20	090/20	070/20	070/20	090/19

a. Comments on winds:

(1) 65% of the forecast wind directions were within 20 degrees of the observed; 88% of the forecast wind directions were within 30 degrees of the observed. The greatest deviation from the forecast winds was 70 degrees at 20,000 feet.

(2) 76% of the forecast wind speed deviated 6 knots or less from the observed, and 82% deviated 10 knots or less. The maximum error was 13 knots at 45,000 feet.

NECTAR

Date 14 MAY 1954 Time 0558 L Clouds lower 3/8 CU/SC Base 2,000

Tops 4000 Middle 6/8 AC/AS Base 12000 Upper 10/10 CS

Visibility 10 Miles Sea Level Pressure 1006.4 Mb Wind direction 090 degrees Velocity 17 Kts

Surface temp 80 °F Dew Point 75 °F Humidity 85 % Vapor pressure .865

Local weather CLOUDY WITH SHOWERS

Remarks Scattered Showers, Sky, Generally Chaotic Appearance

Latest winds aloft taken on Eniwetok Is. Position ______ Time 0600 M

ALTITUDE	DEGREES	KNOTS	PRESSURE	TEMP	DEW POINT	HUMIDITY
Surface	090	19	1006 Mb	25.9 °C	24.7 °C	93 %
1,000 Ft	090	21	968	24.5	22.7	90
1,500	100	20	953	23.6	22.0	91
2,000	100	17	937	22.7	21.1	91
3,000	110	19	905	21.0	19.6	92
4,000	110	19	874	19.3	17.9	92
5,000	110	15	843	17.3	16.2	93
6,000	110	14	813	16.6	15.5	93
7,000	100	12	785	13.8	12.8	94
8,000	100	10	757	10.6	08.3	85
9,000	110	11	730	10.5	06.3	75
10,000	110	14	704	9.3	05.5	77
12,000	120	17	653	5.4	02.6	82
14,000	110	18	606	3.1	00.5	83
16,000	130	12	562	-0.5	-2.8	84
18,000	140	12	522	-4.1	-12.9	50
20,000	130	08	488	-5.8	-18.8	35
25,000	190	06	395	-15.0	MB	MB
30,000	230	17				
35,000	210	09				
40,000	210	24				
45,000	230	32				
50,000	280	35				
51,000	290	38				

REMARKS

BIKINI-NECTAR SHOT, 0620M, 14 MAY 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+6 hours
Surface	0825	0820	No Run Made	0715	No Run Made
2000	0831	0920		0815	
4000	0926	1023		1014	
6000	2122	1225		1122	
8000	1023	1122		1125	
10000	1122	1220		1118	
12000	1116	1322		1317	
14000	1010	1321		1316	
16000	1014	1318		1516	
18000	1210	1320		1516	
20000	1904	1209		1516	
25000	2020	3002		1414	
30000	2615	3424		1414	
35000	2515	2319		1417	
40000	2525	2218		1515	
45000	2239	2431			
50000	2654	2443			
55000	2819	2753			
60000	2741	2949			

ENIWETOK-NECTAR SHOT, 0620M, 14 MAY 1954

LEVEL	H-9 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0721	0625	0919	0720	0920
2000	0926	1127	1017	1121	1017
4000	0923	1123	1119	1117	1414
6000	1027	0814	1114	1012	1615
8000	1010	0913	1010	1211	1614
10000	1305	1113	1114	1314	1714
12000	1310	1214	1217	1410	1917
14000	1214	1212	1118	1214	2018
16000	1111	1311	1312	1216	2015
18000	1005	1313	1412	2007	1915
20000	0103	1807	1308	1518	1913
25000	2709	2308	1906	2104	Calm
30000	2719	2420	2517	2012	Calm
35000	2334	2225	2109	2125	1814
40000	2436	2237	2124	2127	1809
45000	2054	2432	2332	2421	Calm
50000	2843	2838	2835	2824	Calm
55000	2820	2935	2938	3126	2312
60000	3503	1118			2416
65000	0914				
70000	0936				
75000	0946				
80000	0952				

KUSAIE-NECTAR SHOT, 0620M, 14 MAY 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+10 hours
Surface	Calm	Calm	No Run Made	Calm	1307
2000	1210	1716		1616	1415
4000	1513	1616		1610	1315
6000	1410	1618		1707	1513
8000	1410	1616		1911	2104
10000	1609	1412		2014	1912
12000	1817	1514		2212	2208
14000	1718	1516		1915	2210
16000	1621	1616		1614	2311
18000	1820	1613		1616	1912
20000	1621	1516		1420	1513
25000	1517	1619		1517	1513
30000	2314	2302		1708	1613
35000	2604	2908		1106	2304
40000	2611	2618		0904	0908
45000	2523	2513		1610	1616
50000	3225	3424		3406	2505
55000	3326				2607
60000					2521
65000					1706
70000					1033
75000					1142
80000					0952
85000					0968
90000					0965

KWAJALEIN-NECTAR SHOT, 0620M, 14 MAY 1954

LEVEL	H-6 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0711	0714	No Run Made	0712	1111
2000	0913	1019		1124	1409
4000	1017	1122		1224	1414
6000	1218	1220		1316	1419
8000	1114	1215		1112	1318
10000	1113	1214		0909	1316
12000	1117	1114		1014	1417
14000	1216	1012		1106	1418
16000	1213	0915		1108	1317
18000	1411	1211		1210	1517
20000	1515	1510		1609	1414
25000	2013	1611		2016	1902
30000	2109	1909		2120	1312
35000	2109	2010		2123	1404
40000	2421	2510		2325	2006
45000	2738	2525		2524	2517
50000	2956	2730		2825	2914
55000	2557	2944		2817	2924
60000	2631			3305	2518
65000				0620	0903
70000				1046	0928
75000				1049	0841
80000				1142	1160
85000				1061	0726
90000				1060	

MAJURO-NECTAR SHOT, 0620M, 14 MAY 1954

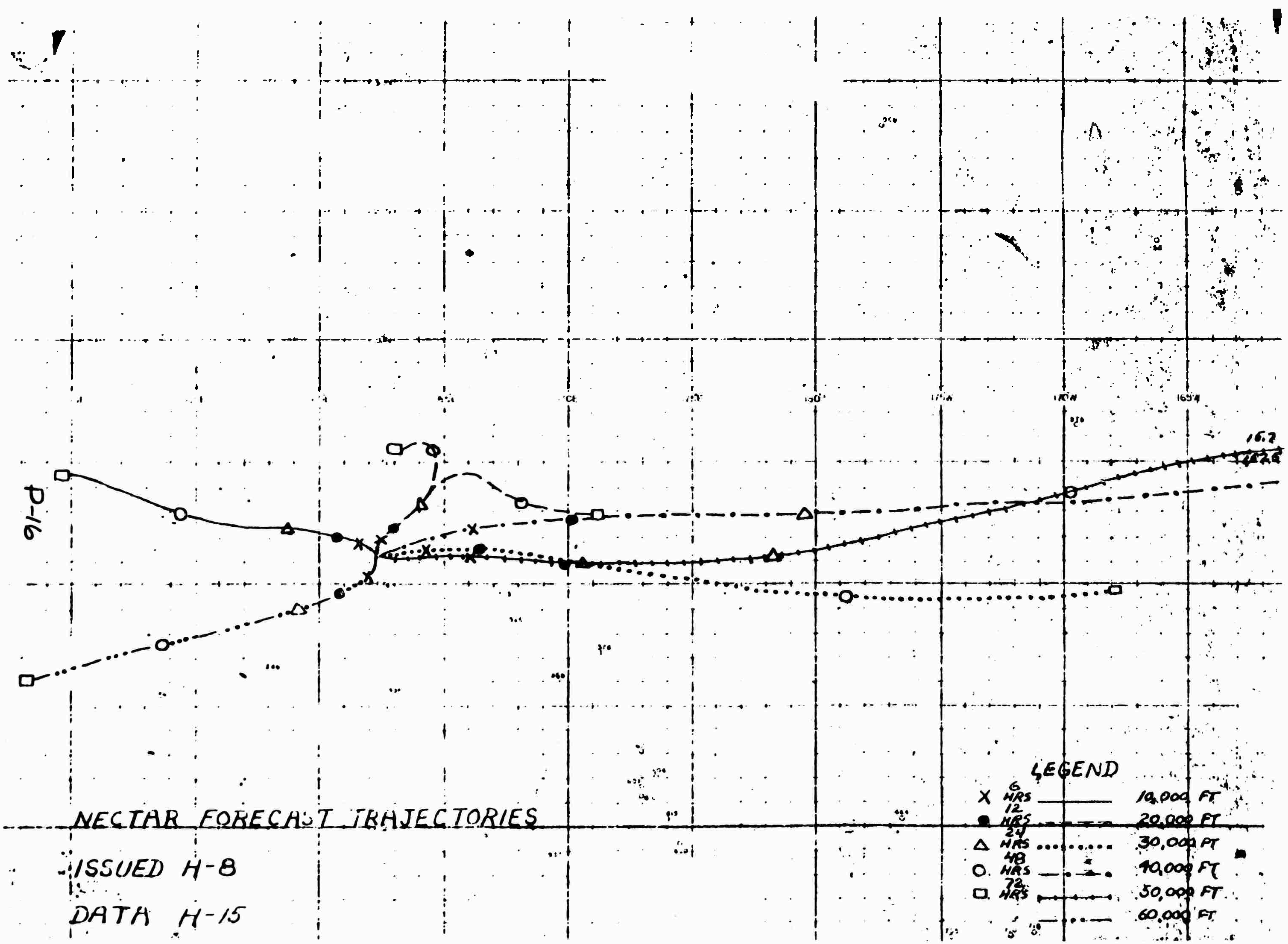
LEVEL	H-9 hours	H-3 hours	SHOT	H+3 hours	H+9 hours
Surface	0909	0909	No Run Made	0907	Calm
2000	0907	1118		1117	0710
4000	1011	1415		1014	0917
6000	1015	1016		1018	1012
8000	1116	0823		1016	1016
10000	1011	0925		0912	0913
12000	0907	0822		0916	1014
14000	0907	0714		0815	1116
16000	1210	0614		0716	0914
18000	1308	0816		0715	1012
20000	1512	0815		0711	1214
25000	1517	1909		0710	1515
30000	1520	1709		0911	1426
35000	1715	1515		1210	2309
40000	2013	1818		2010	2624
45000	2326	2118		2828	2824
50000	2944	2743		3139	3227
55000	2731			2205	2219
60000					1307
65000					0507
70000					0934
75000					0950
80000					0854
85000					0758
90000					0870
95000					0761
100000					0853
105000					0820
110000					0817

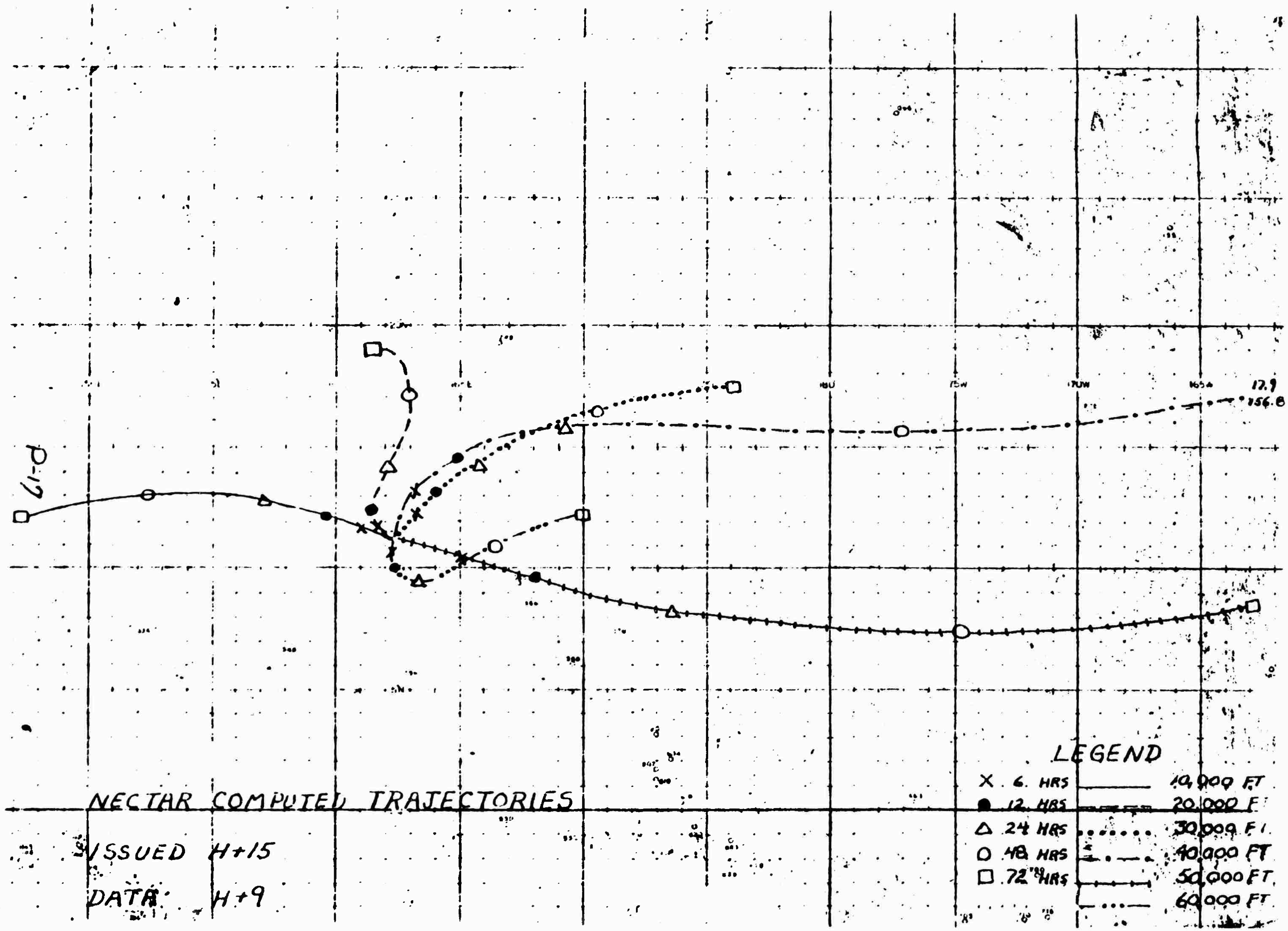
PONAPE-NECTAR SHOT, 0620M, 14 MAY 1954

LEVEL	H-9 hours	H-3 hours	SHOT	H+3 hours	H+5 hours
Surface	0906	0905	No Run Made	Calm	Calm
2000	0822	0924		1316	1610
4000	0829	1020		1317	1613
6000	0839	1115		1316	1618
8000	0647	0713		1508	1808
10000	0635	0619		1614	1908
12000	0633	0529		1416	2206
14000	0627	0529		1317	2220
16000	0614	0527		1219	1922
18000	0521	0623		1010	1825
20000	0613	0721		1010	1525
25000	0628	0717		1010	1615
30000	0811	0308		0810	1810
35000	2105	0912		1110	1810
40000	1907	1306		1111	1617
45000	0918	1311		1209	1006
50000	0909	7604		3024	3307
55000	2705	2705		2918	2004
60000				0804	2405
65000				1218	0410
70000				1140	1225
75000				0857	0952
80000				0855	0961
85000				0973	0967
90000				0961	0997
95000				0998	
100000				0951	
105000				0922	
110000				0909	

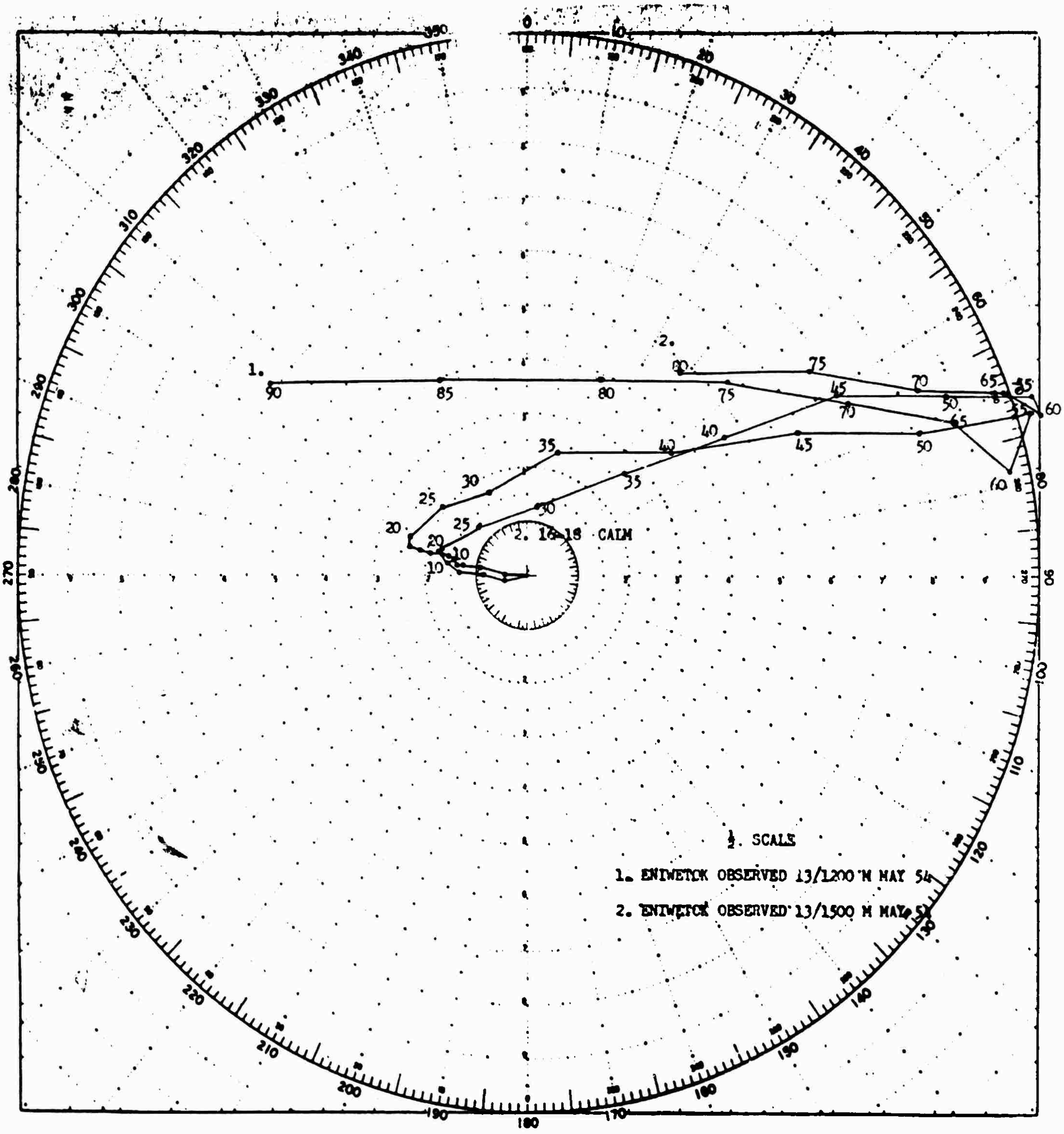
RONGERIK-NECTAR SHOT, 0620M, 14 MAY 1954

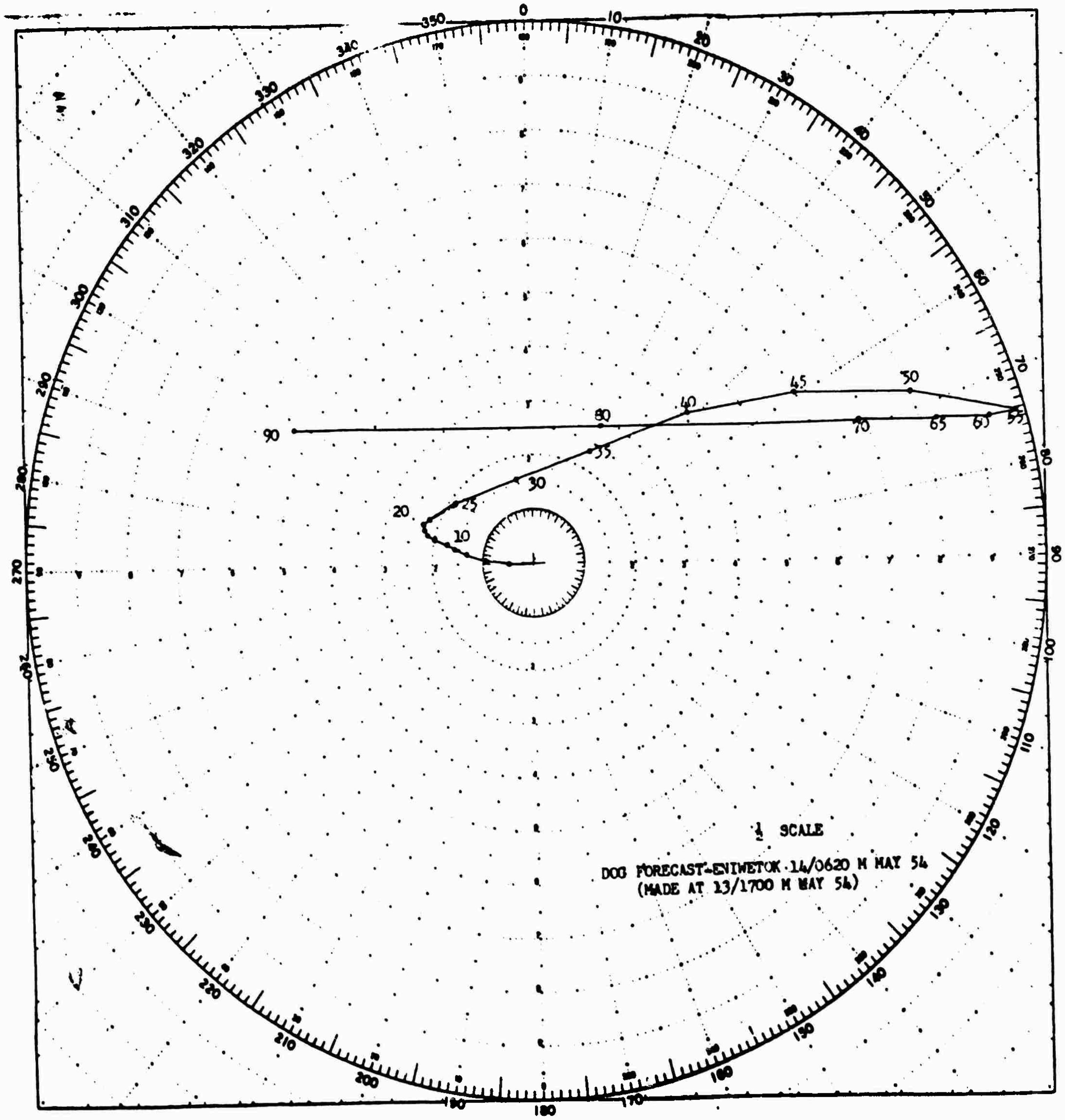
No Observation Made


NECTAR FORECAST TRAJECTORIES
ISSUED H-8
DATA H-15
LEGEND
X 6 HRS
● 12 HRS
△ 24 HRS
O 48 HRS
□ 72 HRS
10,000 FT
20,000 FT
30,000 FT
40,000 FT
50,000 FT
60,000 FT
P-16



P-17
NECTAR COMPUTED TRAJECTORIES
ISSUED H+15
DATA H+9
LEGEND
X 6. HRS
● 12. HRS
△ 24 HRS
O 48 HRS
□ 72 HRS
10,000 FT
20,000 F
30,000 F
40,000 FT
50,000 FT
60,000 FT
180
175W
170W
165W
17.9
156.8


½. SCALE
1. ENIWETOK OBSERVED 13/1200 M MAY 54
2. ENIWETOK OBSERVED 13/1500 M MAY 54
2. 16-18 CALM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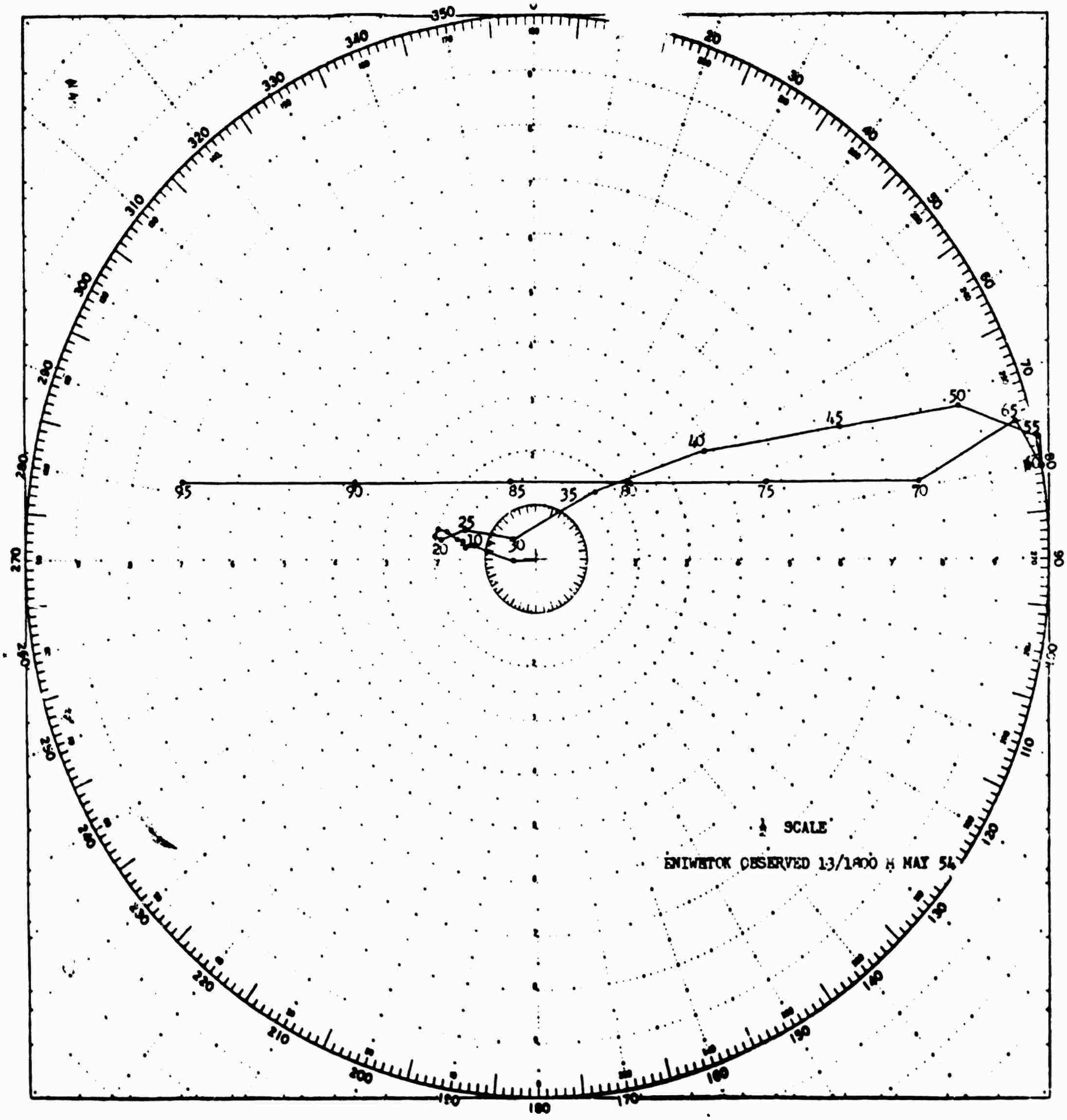
DOG FORECAST-ENIWETOK 14/0620 M MAY 54
(MADE AT 13/1700 M MAY 54)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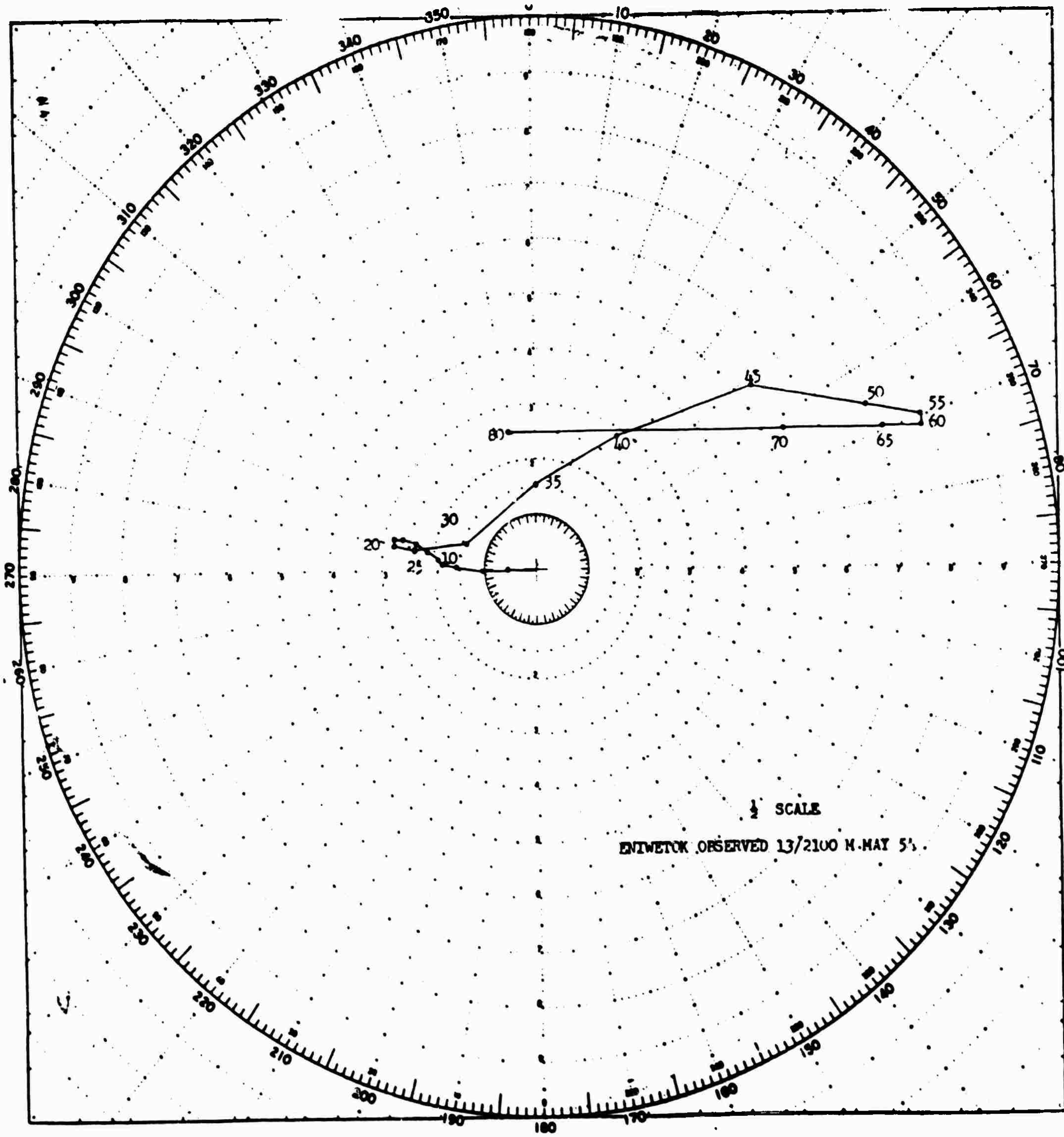
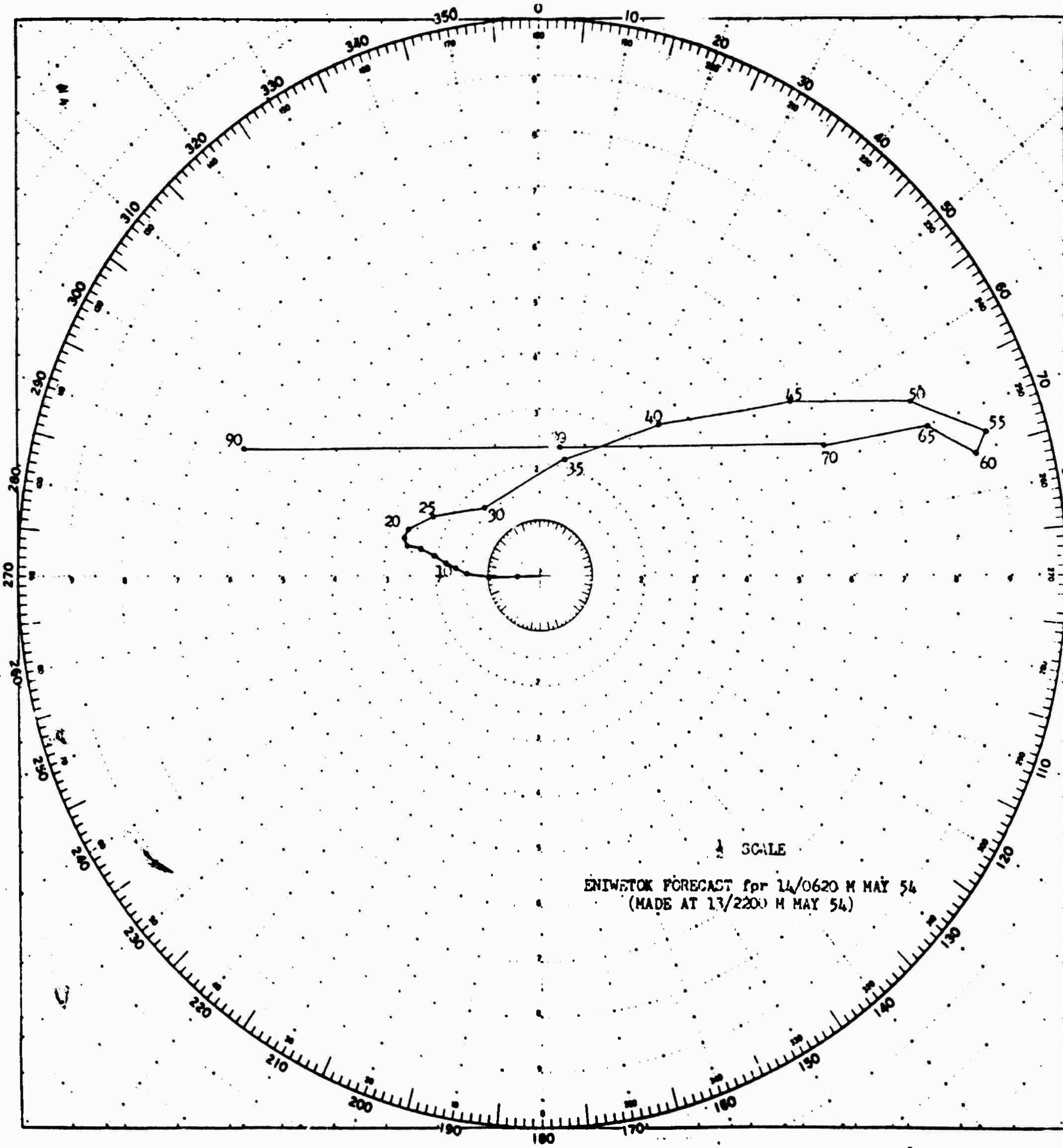
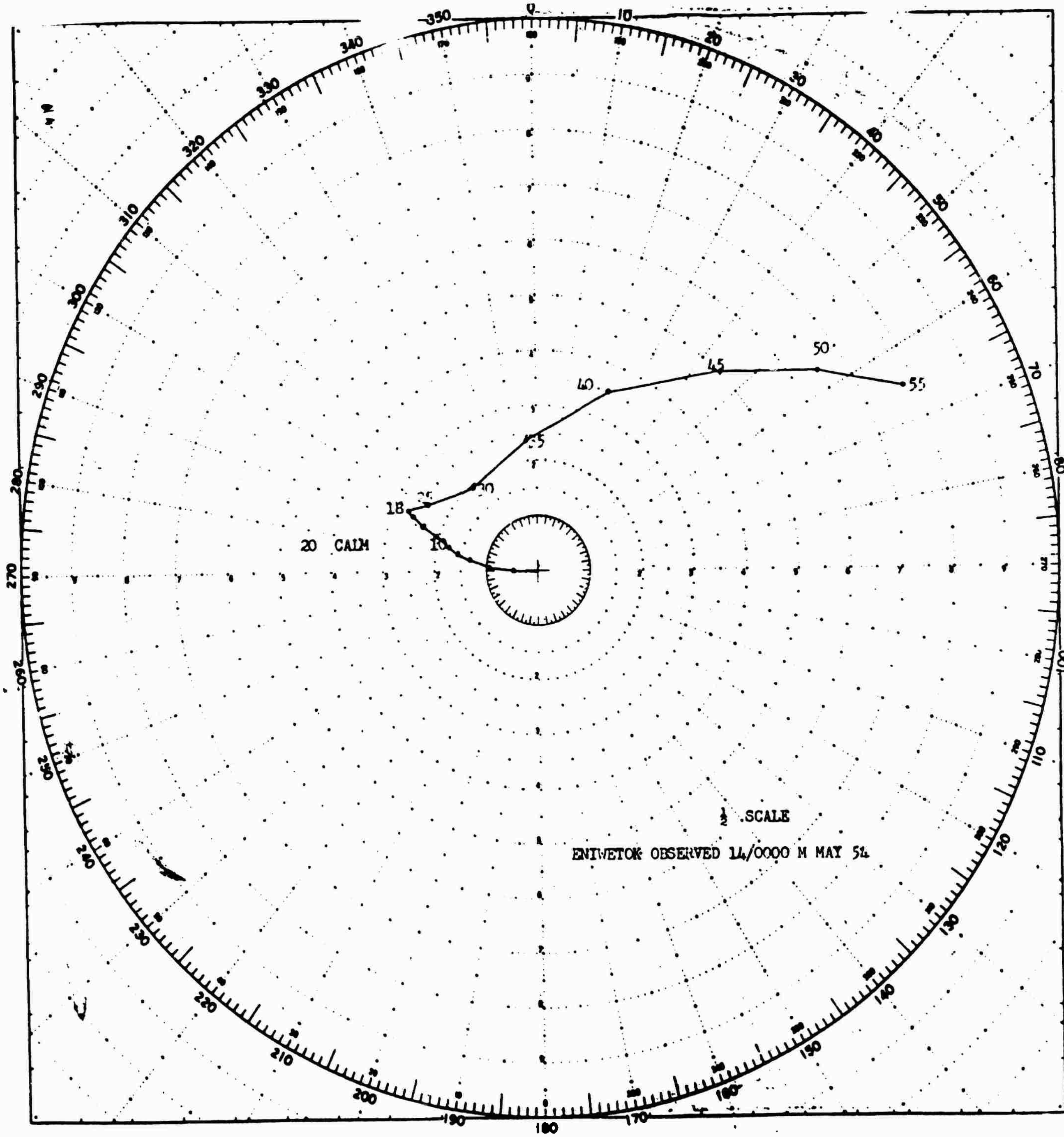
ENIWETOK OBSERVED 13/1800 M MAY 54


½ SCALE
ENIWETOK OBSERVED 13/2100 M MAY 54
350
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340

p. 21

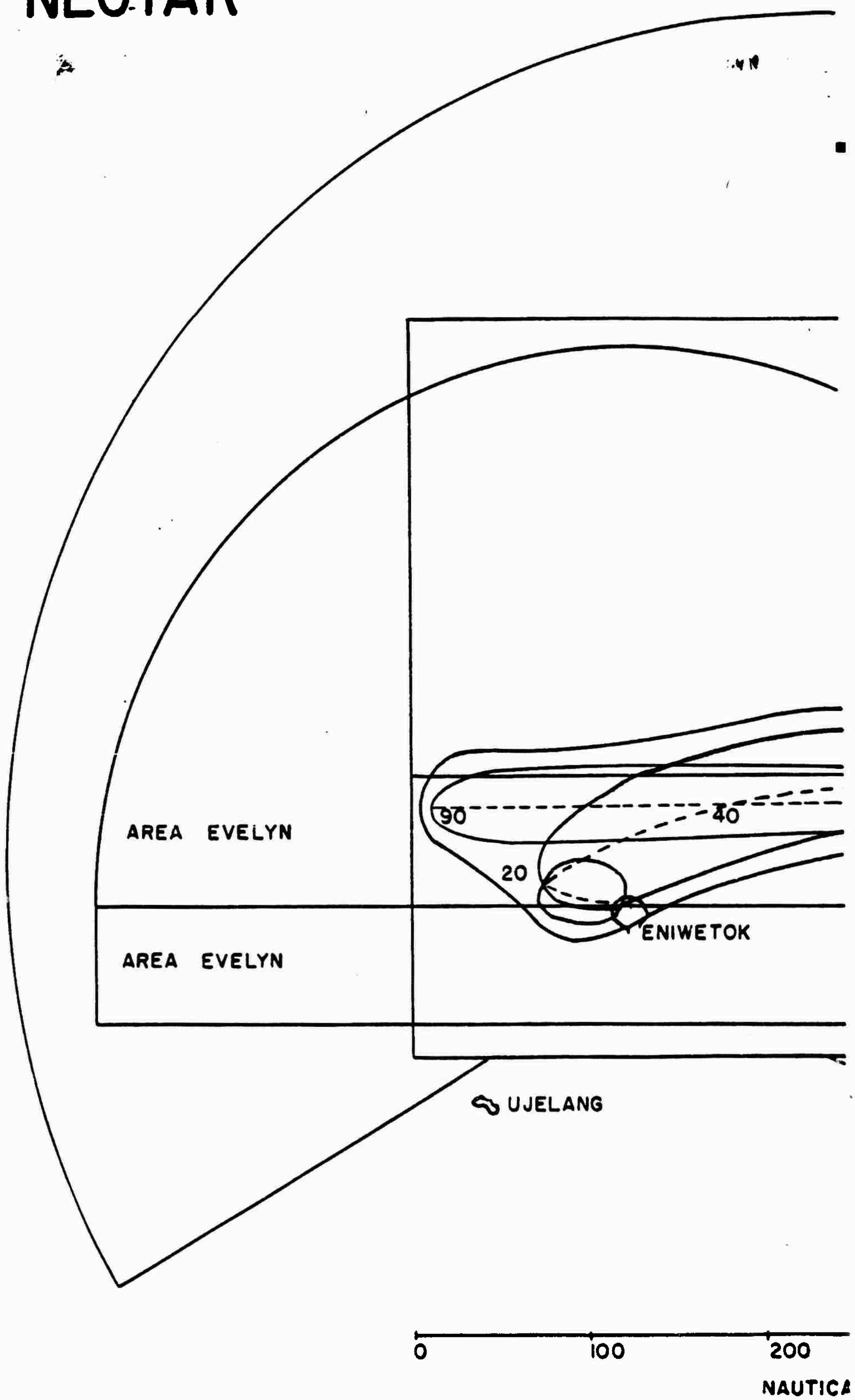

½ SCALE
ENIWETOK FORECAST for 14/0620 M MAY 54
(MADE AT 13/2200 M MAY 54)
90
35
40
45
50
55
60
65
70
30
25
20
10

b-22



20 CALM
½ SCALE
ENIWETOK OBSERVED 14/0000 M MAY 54

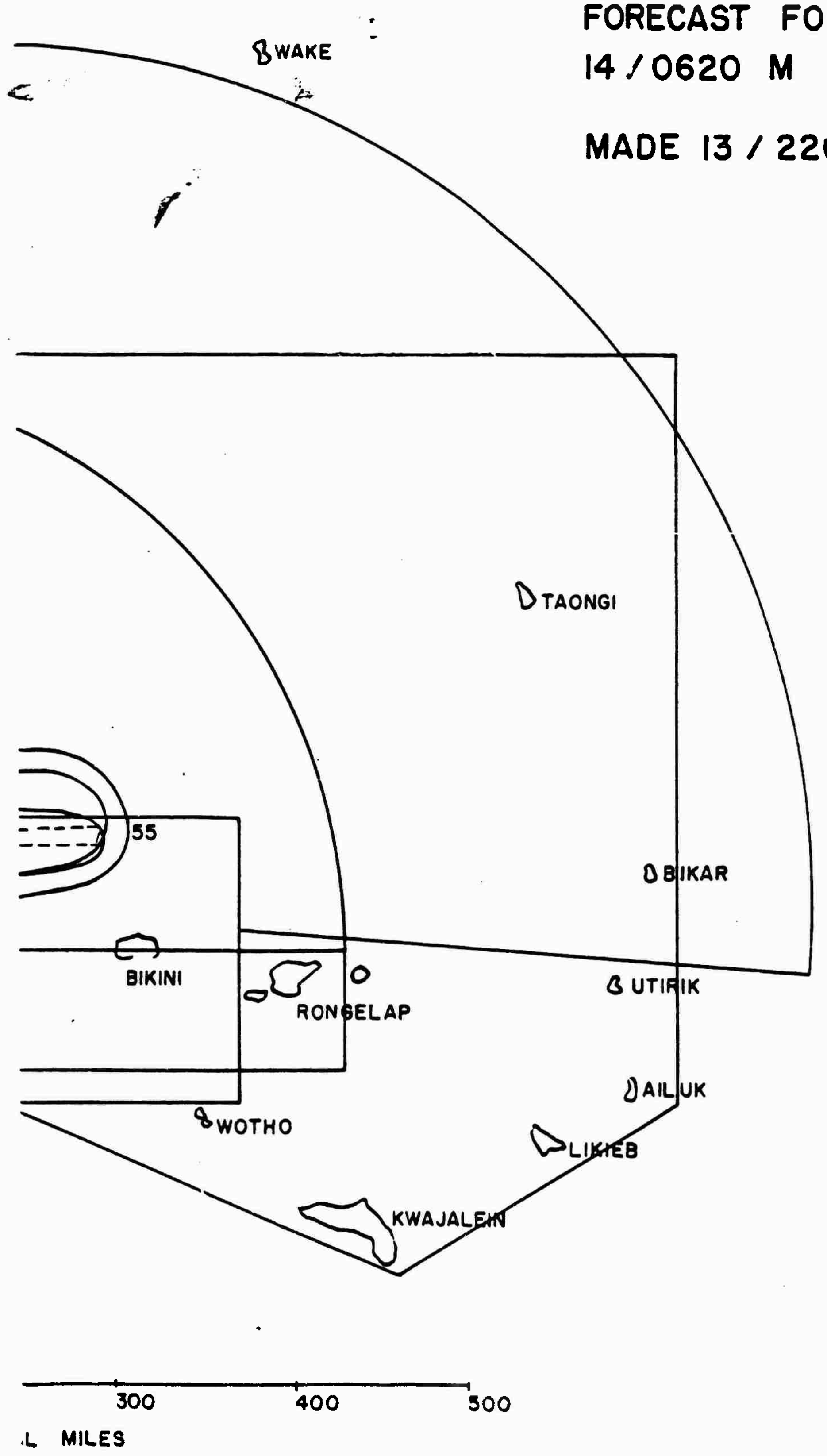
NECTAR



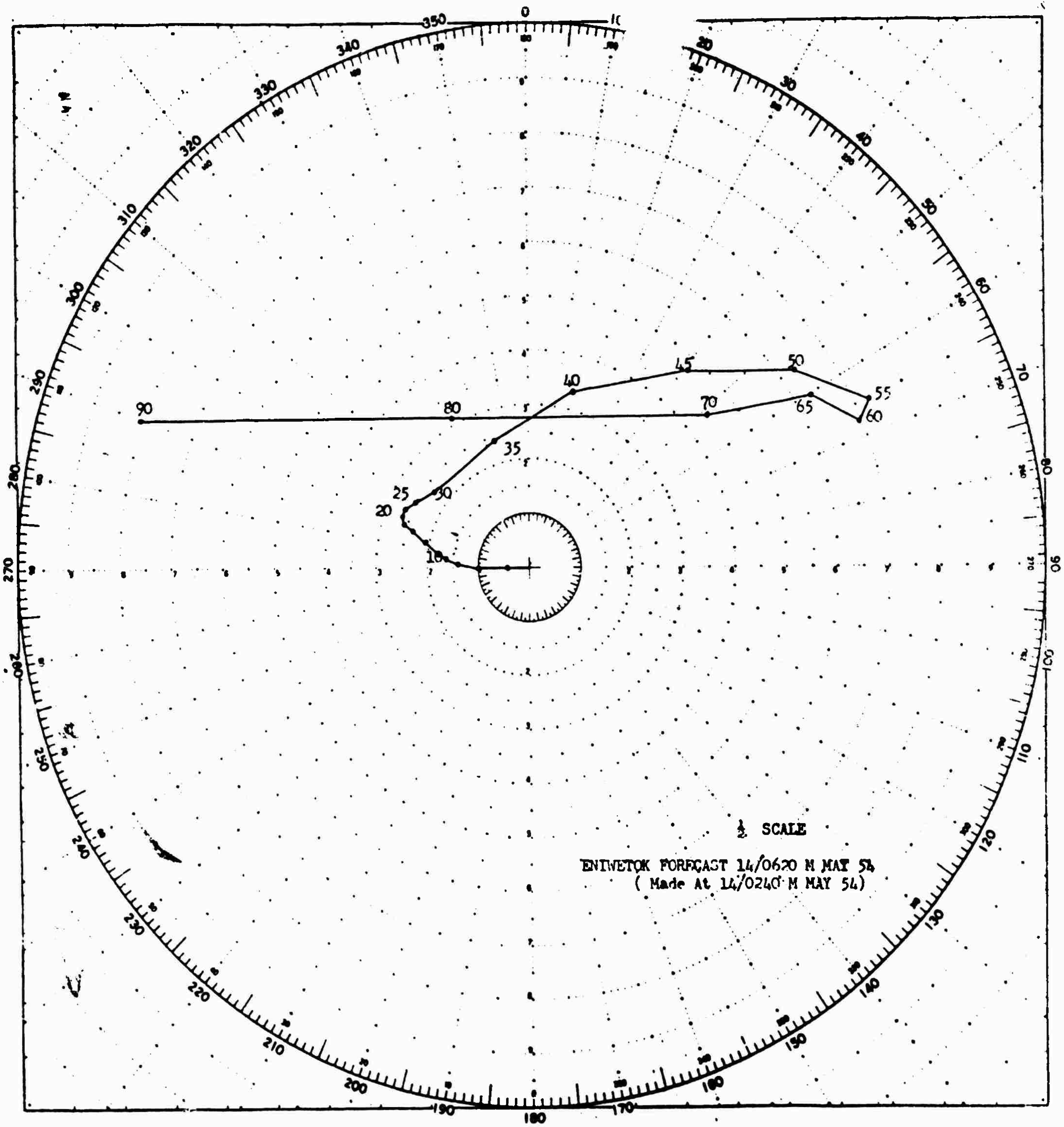
AREA EVELYN
AREA EVELYN
90
40
20
ENIWETOK
UJELANG
0
100
200
NAUTICA

FORECAST FOR
14 / 0620 M MAY 54

MADE 13 / 2200 M

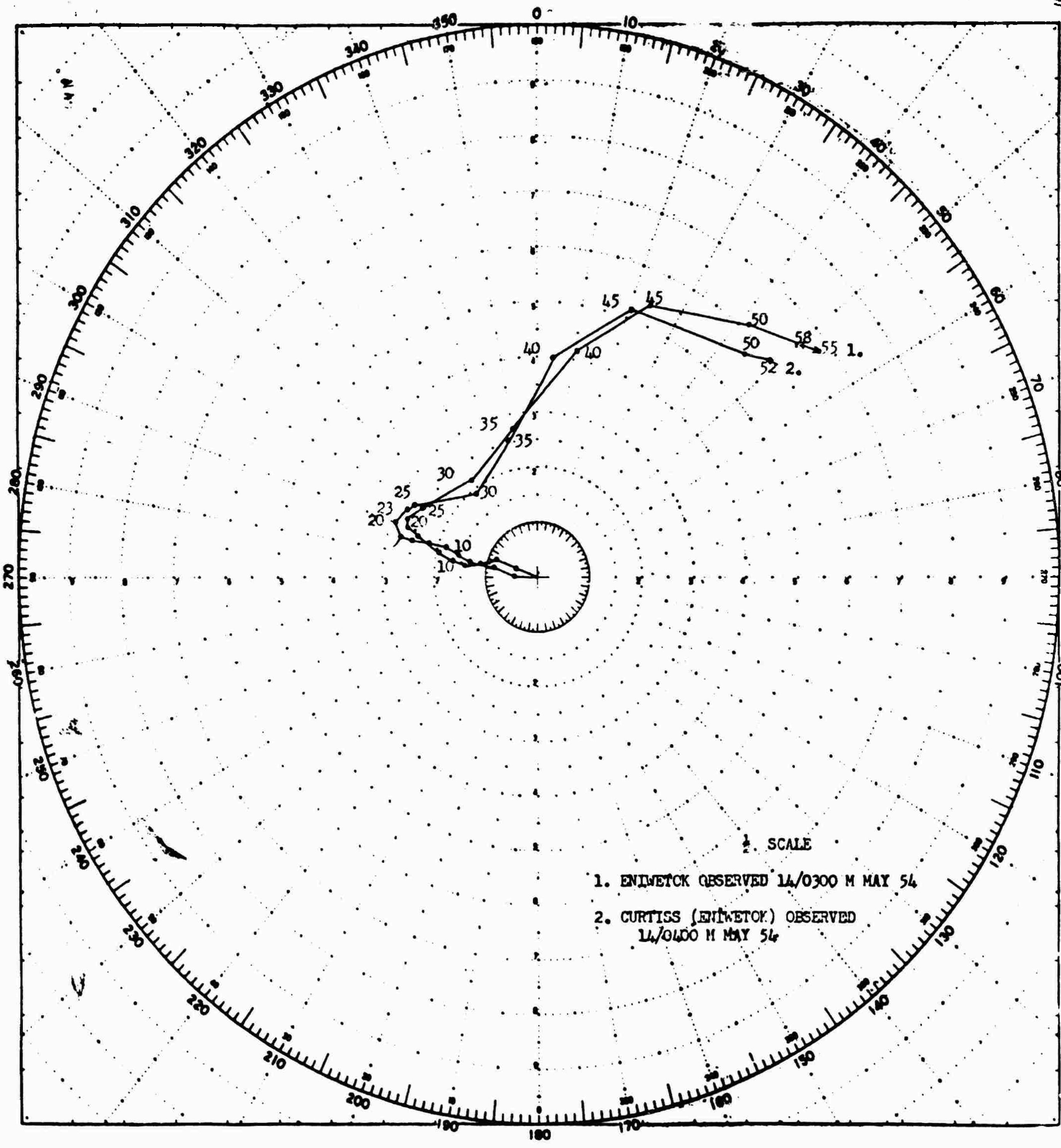


f-24



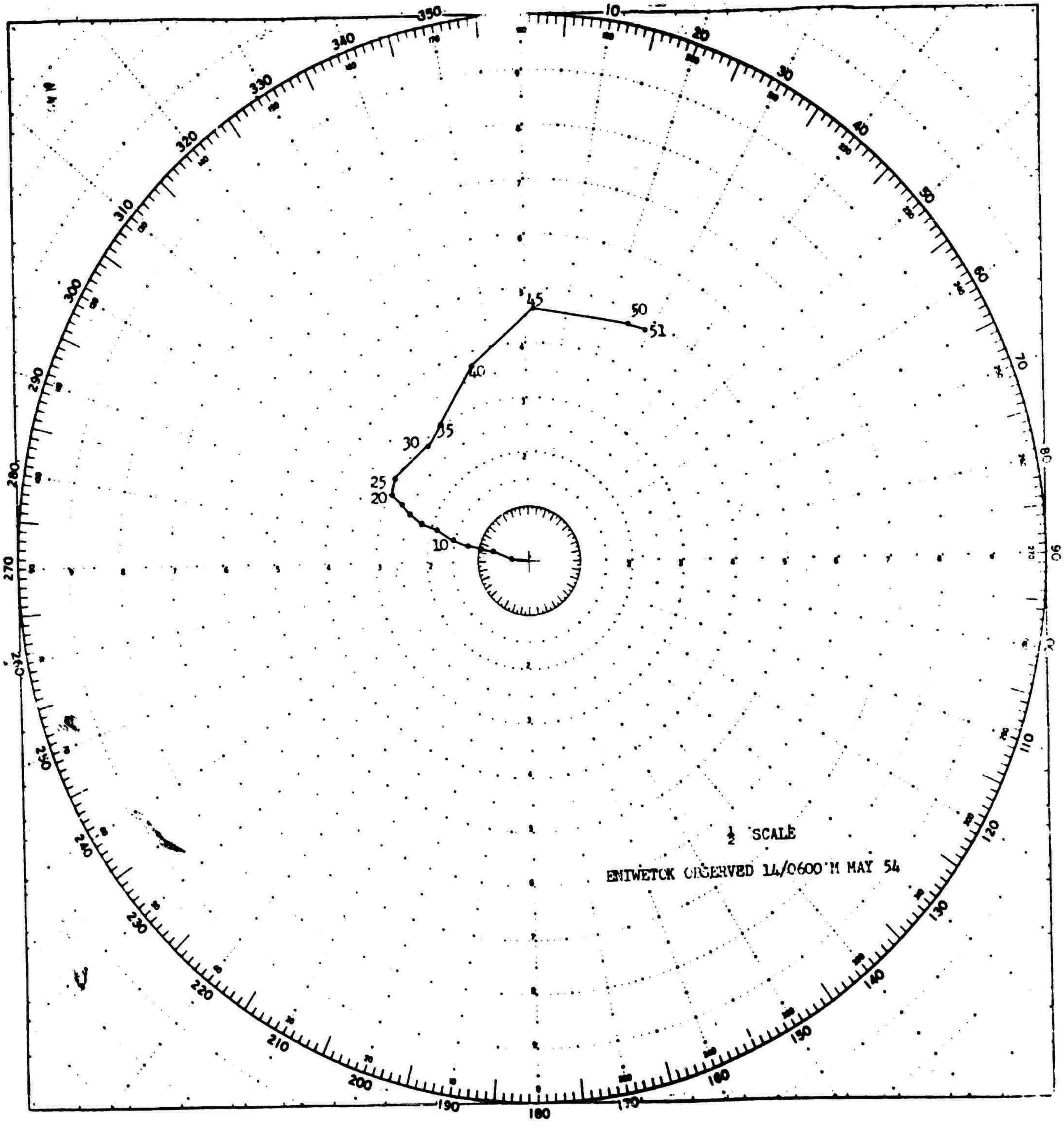
½ SCALE
ENIWETOK FORECAST 14/0620 M MAY 54
(Made At 14/0240 M MAY 54)
90
80
70
65
60
55
50
45
40
35
30
25
20
10

B-25

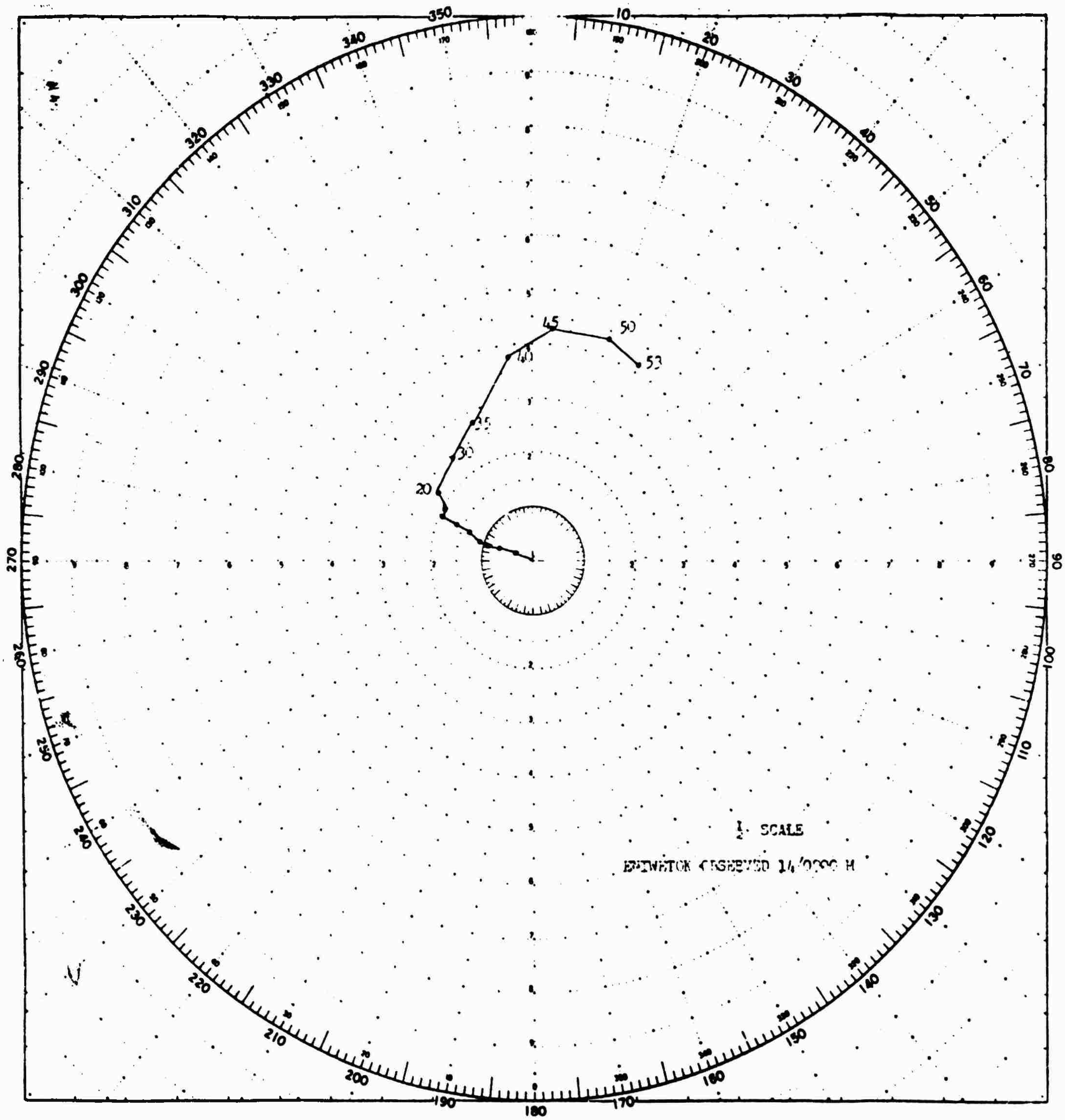


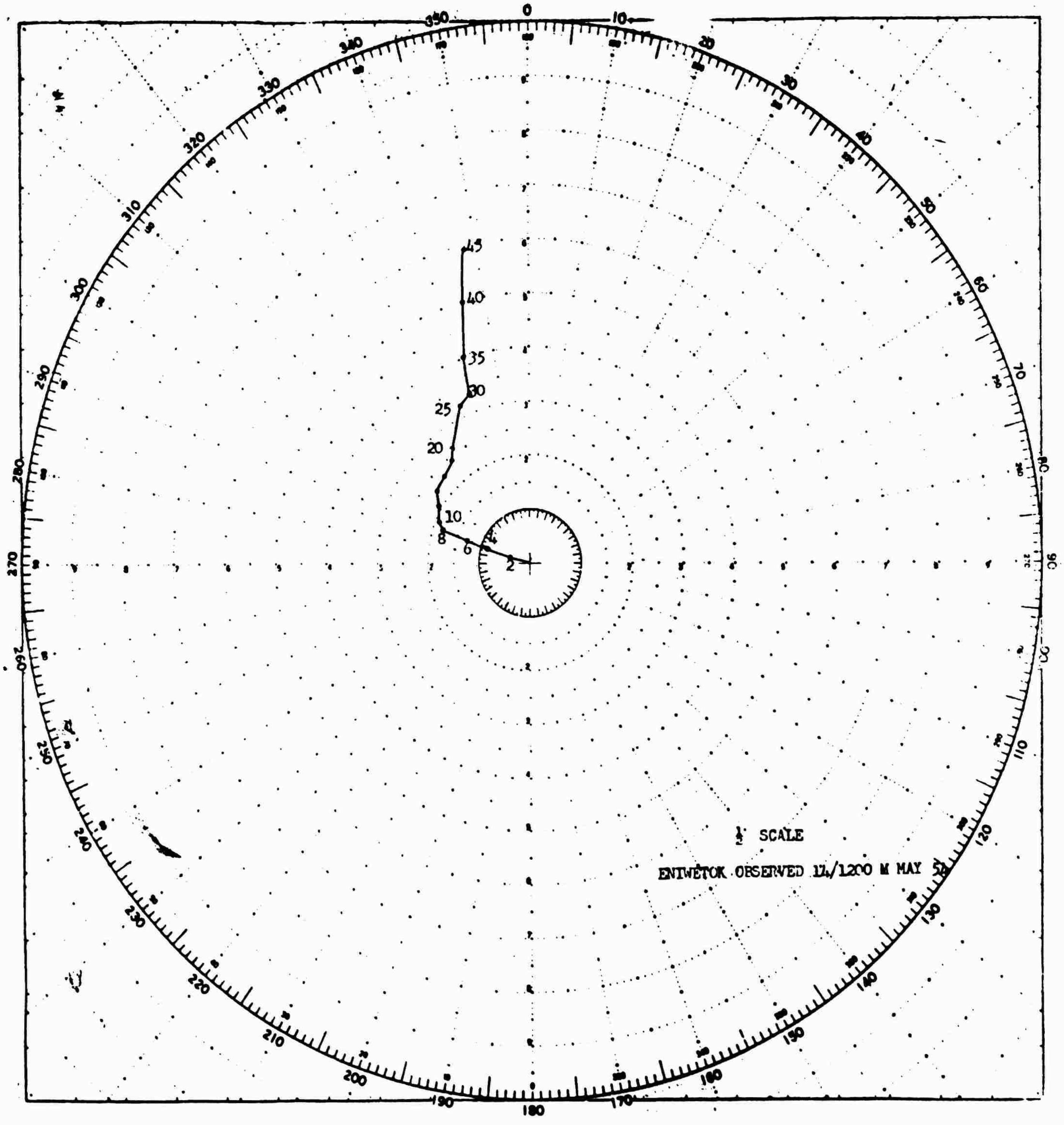
½ SCALE
1. ENIWETOK OBSERVED 14/0300 M MAY 54
2. CURTISS (ENIWETOK) OBSERVED 14/0400 M MAY 54

C-26



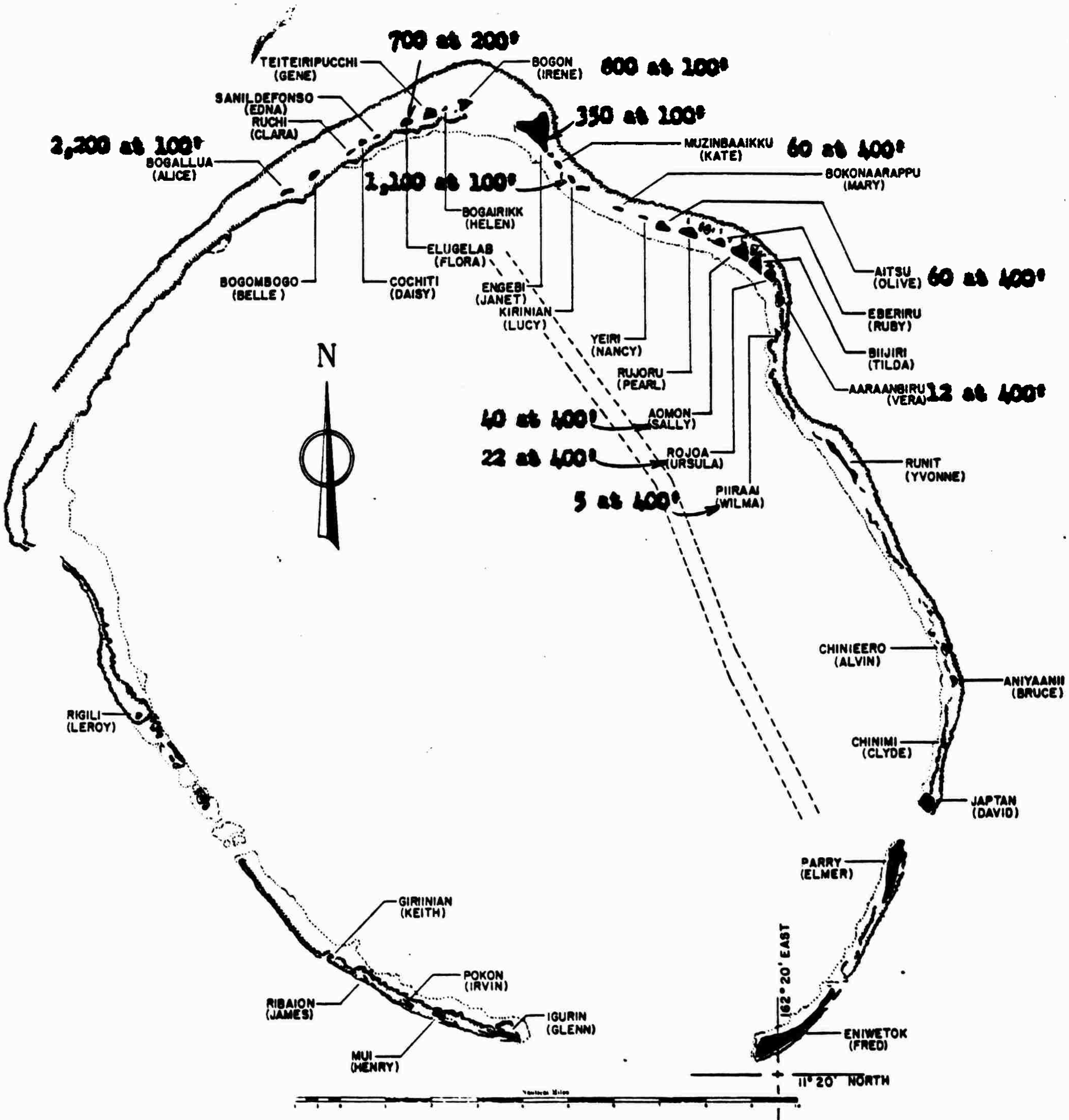
P-27


½ SCALE
20
30
35
40
45
50
53



8.29

MAP OF ENIWETOK ATOLL



Radsafe Survey Readings NECTAR Day (approximately 3/4 hours)

(All readings in mr/hr.)

P-30

AIR RAD SAFE OPERATIONS FOR NECTAR

1. SUMMARY:

The atomic device NECTAR of Operation CASTLE was detonated at 1820 Hours ZEBRA, 13 May 1954 from a barge located in the IVY MIKE crater ENIWETOK ATOLL. NECTAR cloud reached an altitude on the order of 70,000 feet. The Air Rad Safe operations in connection with this detonation were successfully conducted and resulted in much timely information on the Post-event conditions, not only on the shot atoll of ENIWETOK, but also the adjacent areas. Cloud tracking aircraft obtained data which indicated that the lowest section of the NECTAR cloud stem, up to twenty thousand feet, was moving to the west-northwest at approximately 15 knots. This movement, plus the low intensities encountered (a maximum of 2 mr/hr at H plus 5 hours), established the fact that this portion of the cloud did not constitute a hazard to UJELANG ATOLL, 120 miles to the southwest of ENIWETOK. Other later contacts were made to the northeast of GZ. These were primarily low intensities and were undoubtedly from the mid-level cloud between 20,000 and 60,000 feet. From the meteorlogical data (see hodographs) one would predict fall-out from these levels moved to the north initially and then to the west, and that the mid-levels had an increasingly more northerly movement with time after H-Hour. On the basis of the foregoing it was apparent that there was no hazard to the populated atolls within or without the Pacific Proving Ground, with special consideration given to UJELANG. This premise was verified by a destroyer on direct course from UJELANG to ENIWETOK on the afternoon of that day and again by subsequent precision aerial survey flights (NYKOPO Flight ABLE on plus one day, and Flights ABLE, BAKER and CHARLIE on plus two days). There was no evidence of significant fallout outside the Pacific Proving Ground.

2. GENERAL:

a. Sources of Information:

Cloud tracking information for NECTAR was available from four sources. The contribution of each of these sources, which are listed below, will be discussed in subsequent paragraphs.

Sampling Aircraft Reports
Sweet-Sour Reports
Special Cloud Tracking Flights
AFOAT-1 Flights

(Note: NECTAR being the last shot of the series, weather reconnaissance ceased at H-hour. Consequently, no long-range coverage was available on areas normally of mutual weather/radsafe interest. Since such areas were not ordinarily critical from a radsafe point of view, and consiering the NECTAR wind pattern, this loss was of minor consequence.)

Incl: 6

b. Over-all Cloud Movement (within the PPG):

The observed ENIWETOK winds on NECTAR Day are plotted in the hodographs. From the hodographs it can be seen that the NECTAR cloud, whose maximum height was of the order of 70,000 feet, was influenced by two wind shears: The lowest level of the cloud (surface to 20,000 feet) was driven by winds from the east southeast which averaged 15 knots. Since this segment of the cloud had a southerly component, no contamination was expected to move toward UJELANG. This was verified by the two cloud trackers operating southwest and west of GZ from H plus 2 to H plus 5 hours. The only contacts made by these aircraft were very low intensities at the northern part of their racetrack holding pattern. The initial movement of the middle cloud 20,000 to 40,000 feet was influenced by the generally southerly winds at these levels which had an average velocity of 20 knots. As indicated in the hodographs, the depth of the southerlies in this layer increased to 45,000 feet by H plus 6 hours. The forecast, as amended by later wind observations, was essentially verified by the cloud trackers, all of which were subsequently used to search upwind in the northeast quadrant. All significant fall-out appeared confined to an area north and north-northeast of GZ. No atolls were materially affect d by the NECTAR cloud.

3. SAMPLING AIRCRAFT REPORTS:

As in the case of previous shots, these reports were recorded by Rad-Safe personnel at the Command Post on ELMER from plus two to plus six hours. Reports from these aircraft provided the first data available on the maximum cloud height and initial cloud movement. The sampling activities of the planes confirmed the accuracy of the forecast air RADEX to some extent, however, due to the great amount of cloud cover (in layers from 2,000 to 50,000 feet), actual contacts with GILDA (the atomic cloud and associated fall-out) were few. As would be expected, the average radiation exposure of the aircraft crews was relatively low.

4. SWEET-SOUR REPORTS:

These reports were submitted by any aircraft encountering radioactive contamination and not reporting by other means. No such reports were received following NECTAR.

5. SPECIAL CLOUD TRACKING (WILSON FLIGHTS):

a. The initial phases of the NECTAR cloud tracking effort duplicated those which were so successfully employed for previous shots. Two WB-29's WILSON TWO and WILSON THREE, were placed in a holding pattern fifty miles west southwest of GZ at plus two hours. As will be seen from Appendix I, the location and orientation of this pattern was such than any low cloud segment moving toward UJELANG should be intercepted by both these aircraft. Instead of centering the holding pattern on the line between ENIWETOK and UJELANG, two thirds of the pattern was placed north of this line in order to increase the probability of picking up some of the contamination moving to the west northwest in the lowest shear level.

b. As indicated in App I, only a few contacts were made in the holding pattern, and these were of low intensity. Since these contacts were low and in a region well north of a direct line from GZ to UJELANG, both WILSON aircraft were ordered upwind to the northeast quadrant at approximately 0000 Zebra (plus 5½ hours) and destroyer (stationed at UJELANG to monitor for radiation and to be on the spot for an evacuation should such become necessary) was ordered back to ENIWETOK upon recommendation of RadSafe.

c. Subsequent contacts by the WILSON aircraft were minor, and served mainly to verify the forecast as modified by the observed deepening of the southerlies throughout shot day.

d. WILSON flights subsequent to WILSON FOUR were cancelled when it appeared that no appreciable air contamination existed in the vicinity of the test site except to the north.

6. AFOAT-1 FLIGHTS:

AFOAT-1 sponsored flights made sample collections of radioactive debris at several remote locations. In all cases debris was found to be widely dispersed through out the general area, and of a very low intensity. Further there is considerable doubt as to the samples eminating wholly or partially from the NECTAR detonation. The results of these collections are tabulated below:

Z Time	Position	Altitude	Counts/min/hr
160824Z-161134Z (plus 60-63 hrs)	12N161W-12N 168W (600 miles SW Hawaii)	18,000	9,000
171600Z-171920Z (plus 96-99 hrs)	05N 158W - 10N 165W (840 miles S. Hawaii)	18,000	20,000
180700Z-181115Z (plus 109-113 hrs)	06N 156W-21N 158W (900 miles S Hawaii)	10,000	16,500
150112Z-150135Z (plus 31 hrs)	14N 152E-14N 153E (660 miles NW Guam)	2,000	270,000
160400Z-160458Z (plus 58 hrs)	12N 146E-11N 145E 1,000 miles W Guam)	2,000	25,000

7. IN-FLIGHT EXPOSURES:

All in-flight exposures of the aircraft crews participating in the cloud tracking effort were well within the Task Force limitations.

8. AIR RADEX:

Because of the few sampling aircraft contacts following the shot, only a general verification of the early cloud movement as predicted by the Air RADEX can be assumed. Based on later cloud tracking and low-level over-water surveys by the Health and Safety Laboratory, NYOO, it appeared that the RADEX was reasonably valid.

9. CONCLUSIONS:

a. The Air Rad Safe operations for NECTAR were successful. In particular, the cloud tracking operations early established the fact that there were no elements of the NECTAR cloud which necessitated the evacuation of nearby atolls.

b. Assuming that the forecast winds and trajectories are reliable, resonably accurate forecasts can be made of the areas which will be subject to fall-out.

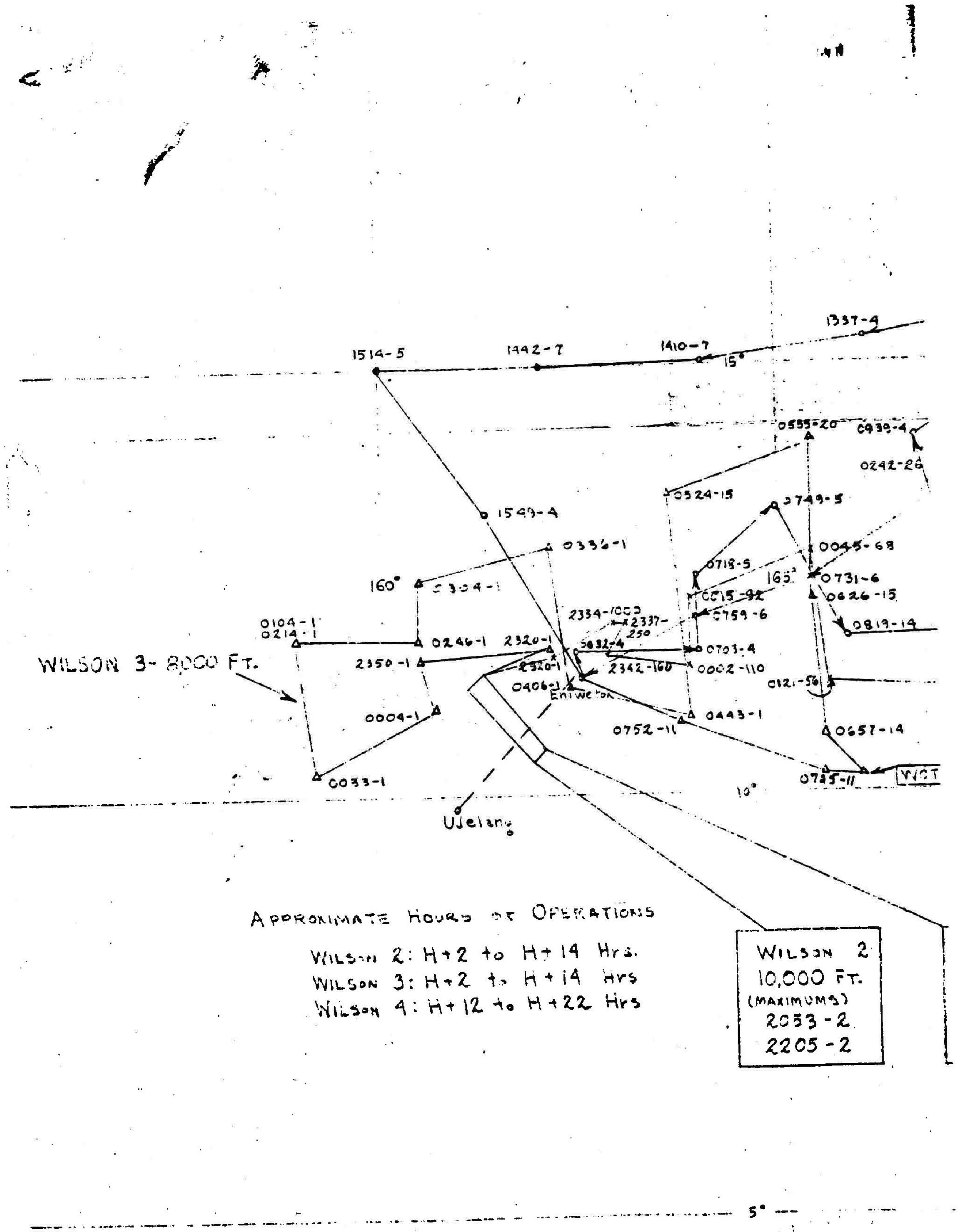
c. No hazardous fall-out was forecast for the GUAM, PONAPE or HAWAII areas as a result of NECTAR.

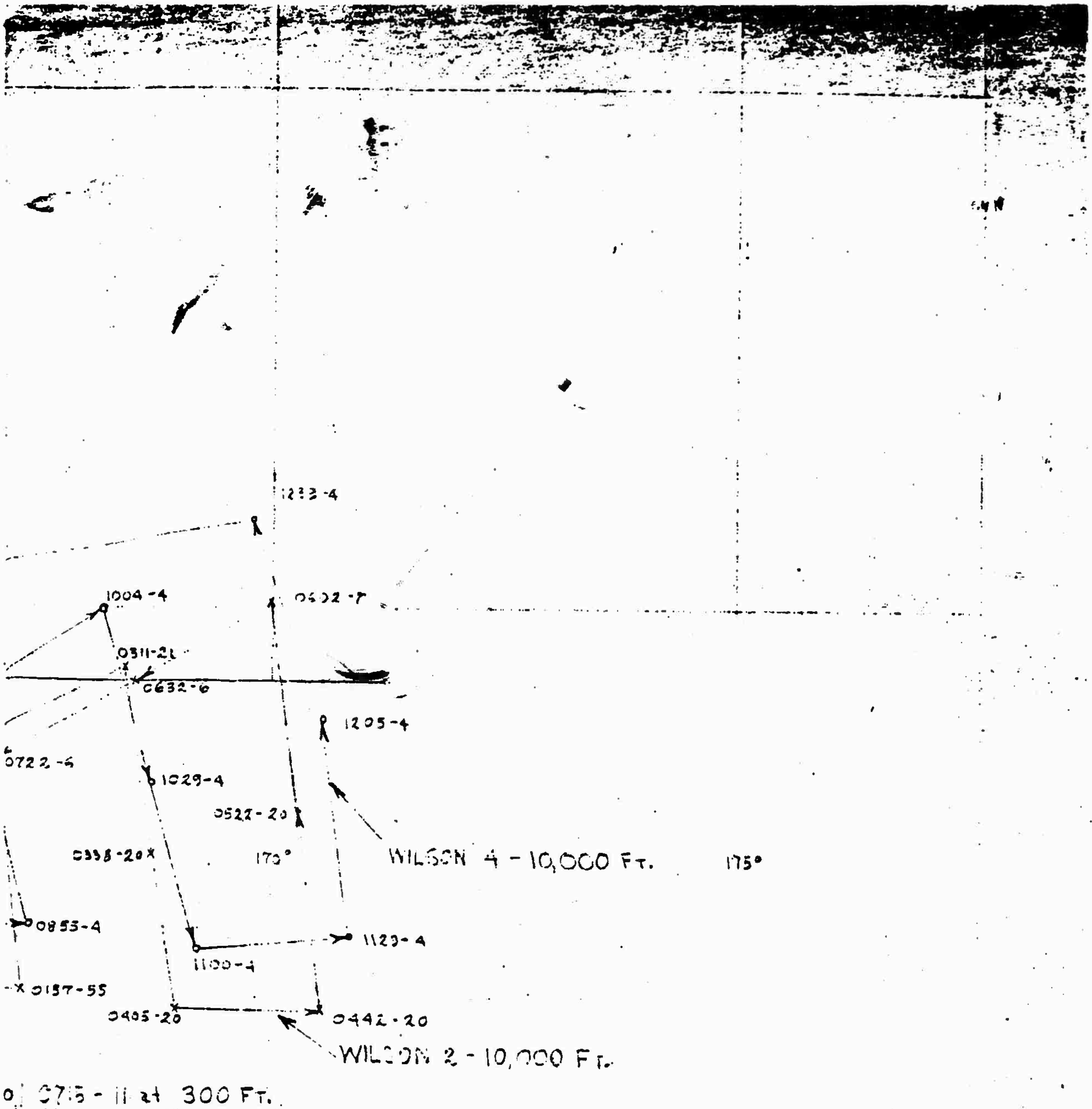
10. RECOMMENDATIONS:

None.

1 Appendix:

Wilson A/C Plot


1337-4
1514-5
1442-7
1410-7
15°
0555-20
0939-4
0242-26
0524-15
0749-5
1549-4
0336-1
0045-68
0718-5
165°
0731-6
160°
0304-1
0015-92
0626-15
2334-1000
2337-250
0759-6
0819-14
0104-1
0214-1
0246-1
2320-1
0032-4
0703-4
WILSON 3- 8000 FT.
2350-1
2320-1
2342-160
0002-110
0406-1
Eniwetok
0121-56
0004-1
0443-1
0752-11
0657-14
0725-11
0033-1
10°
Ujelang
Approximate Hours of Operations
Wilson 2: H+2 to H+14 Hrs.
Wilson 3: H+2 to H+14 Hrs
Wilson 4: H+12 to H+22 Hrs
Wilson 2
10,000 Ft.
(maximums)
2053-2
2205-2
5°



CLOUD TRACKING - NECTAR

13/1820 ZEBRA MAY-54

ALL TIMES ZEBRA → 1234-5

ALL READINGS IN mr/hr →

(Readings include aircraft background.)

Kwajalein

WILSON 3
5000 FT.
(MAXIMUMS)
2020-2
2215-1

369

PRELIMINARY RESULTS

NYKOPO AIRBORNE MONITORING SURVEY FLIGHT O/A 15 MAY 195[illegible]
(Conducted by Health and Safety Laboratory, New York Operations Office, AEC)

LOCATION (Atoll unless otherwise indicated	LOCAL TIME (May)	MAXIMUM GROUND READING (in mr/hr)	LOCAL TIME (May)	MAXIMUM GROUND READINGS (in mr/hr)
FLIGHT ABLE				
KWAJALEIN	151335	0.1	161236	0.08
LAE	150722	0.2	160647	0.08
UJAE	150733	0.08	160657	0.06
WOTHO	150800	0.08	160722	0.08
AILINGINAE	150854	1.4	160823	0.8
RONGELAP IS.	150907	5.8	160836	4.2
RONGERIK	150925	5.8	160854	3.0
TAONGI	151046	0	161006	0
BIKAR	151142	3.0	161103	1.7
UTIRIK	151204	1.0	161124	0.8
TAKA	151208	1.0	161125	0.6
AILUK	151228	0.4	161134	0.1
JEMO	151248	0.4	161157	0.2
LIKIEP	151335	0.1	161202	0.1

MAXIMUM GROUND READINGS OTHER NYKOPO FLIGHTS (IN MR/HR)

FLIGHT BAKER (16 May): 0.15

FLIGHT CHARLIE (16 May): 0.1

SUMMARY OF THE STATUS OF TRANSIENT SHIPPING IN THE PPG AREA O/A 14 MAY 195[illegible]

1. Task Force sources of information.

a. USS NAMAKAGON (AOG-53) ETD ENIWETOK 131200M for KWAJALEIN, SOA 13 knots.

b. USS EPPING FOREST (LSD-4) 9-40N, 172-10E, SOA 13 knots, ETA KWAJALEIN 141200M.

c. USS APACHE depart BIKINI 132200M with YC 1081 in tow via route points 10-55N, 166-10E, 10-55N, 175-00E, thence great circle to PEARL, ETA PEARL 250800Z.

d. USNS MERRELL, ETA GUAM 15 May.

e. Negative search in Area EVELYN N-1 day.

2. COMNAVFORMARIANAS source of information.

a. No PacMicronesian Line vessels in the area.

Inclosure 8